TRAFFIC QUALITY ON THE COLUMBUS REGIONAL HIGHWAY SYSTEM

(FALL 2002)

FINAL REPORT

Prepared by
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for the Georgia Department of Transportation

Skycomp

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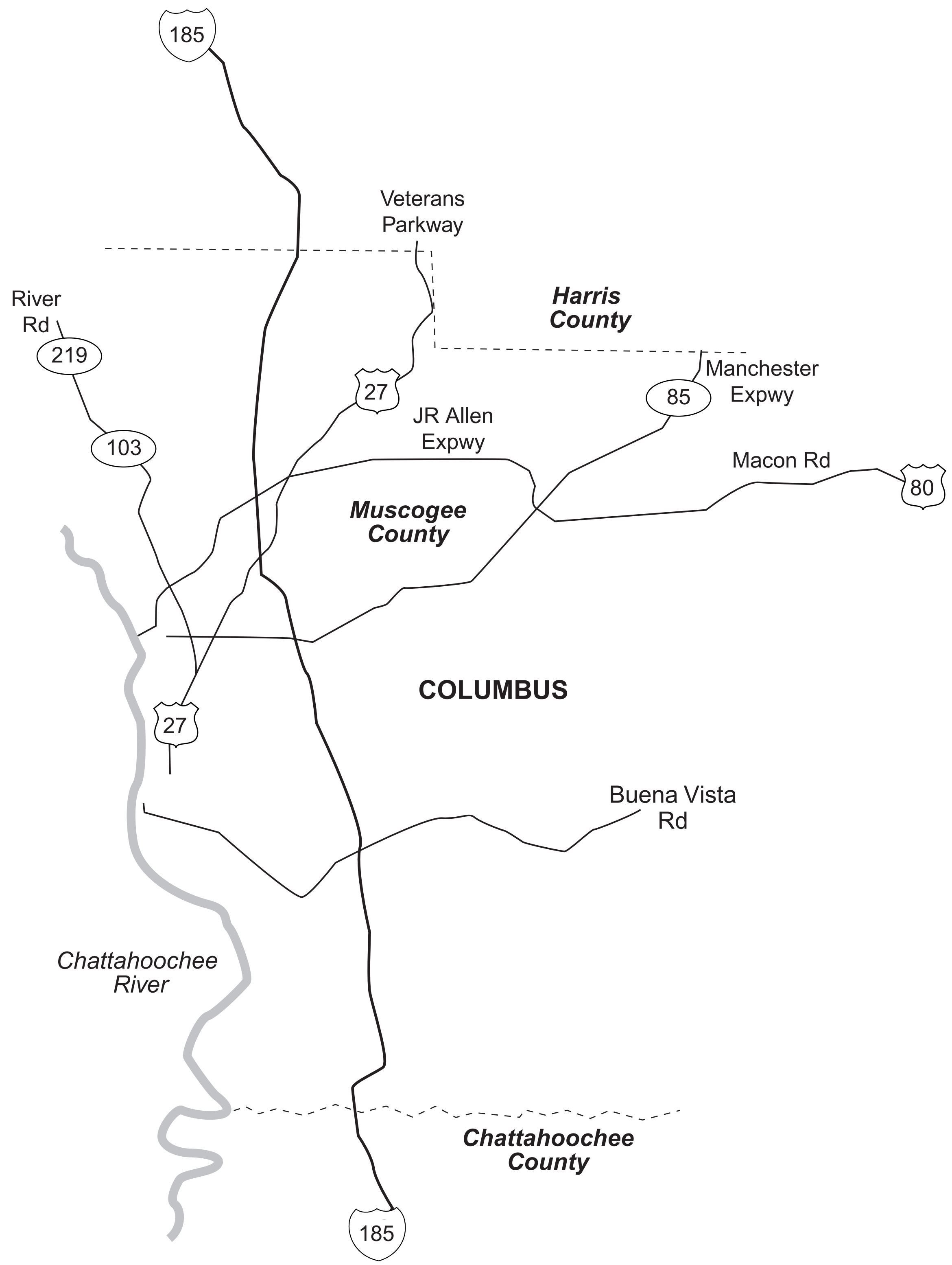
COLUMBUS, GEORGIA
SURVEYED HIGHWAYS



INTRODUCTION

In the fall of 2002, Skycomp conducted an aerial photo survey of traffic conditions on approximately 80 miles of highway in the Columbus metropolitan region; using the mobility and vantage point of fixed-wing aircraft, a photographic inventory of traffic conditions was made on each designated highway. The 2002 aerial survey establishes a baseline of traffic conditions which is suitable for the long-term monitoring of trends and assessing the effects of improvements.

FEATURES OF THE AERIAL SURVEY PROGRAM

During this aerial survey program, overlapping photographic coverage was obtained of each highway, repeated approximately once an hour over four morning and four evening commuter periods. The morning times of coverage were 7:00-9:00 a.m., and evening times were 4:00-6:00 p.m. Survey flights were conducted only on weekdays, except that Monday mornings, Friday evenings and mornings after holidays were excluded. Data were extracted from the aerial photographs such that, by link and by time slice, average recurring daily traffic conditions could be measured. This report presents these measurements in the following ways:

1. Performance rating tables of traffic conditions on the 80 miles of surveyed highways are presented in this report. The ratings are presented in tables by highway segment, by direction and by time slice (1/2 hour time slices). Each rating typically represents the average of two flyovers (from two different days), minus any data affected by incidents. For uninterrupted-flow facilities, the ratings are density-based level-of-service (LOS) designations "A", "B", "C", "D", "E" and "F", as defined in the *2000 Highway Capacity Manual* (HCM). For interrupted-flow facilities, a surrogate level-of-service measure has been used. Developed by Skycomp for use with overlapping aerial photographs, this surrogate measure is based on platoon sizes and queuing characteristics at signalized intersections -- not travel times, which is the defining parameter for arterial LOS in the HCM. Because this is a surrogate LOS measure, the same letters "A" through "F" have been used; however, these ratings have been underlined to identify them as *surrogate* LOS measures ("<u>A</u>", "<u>B</u>", "<u>C</u>", etc.). Note: The procedures for arriving at the performance ratings have been outlined in **Appendix A**.

2. Also in this report, narratives clarify the severity and frequency of all level-of-service “E” and “F” congestion found along each highway segment. Where evident, apparent causes of the problems are also described. Congestion on cross roads and on interchange ramps are also depicted and discussed.

3. In order to allow for the estimation of average travel speeds from densities on freeways, Skycomp has collected data in other cities where aerial surveys have been conducted. A staff member of the Metropolitan Washington (D.C.) Council of Governments used these data to calibrate a single regime model developed in 1995 by Michael Van Aerde. The result was a table for which the typical speed of traffic can be looked up for any density value.
The details of this work are provided in **Appendix B**.

4. A primary deliverable for this project is an electronic version of the Survey Database (built in Microsoft Access). This database contains all of the collected data, from vehicle counts and road segmentation to flight information and the variables used to calculate densities. Using this database, a number of reports can be displayed or printed, including segment densities (averaged or by individual observation), vehicle classification, and incident information. Since all data are saved in a relational database format, it is possible to customize an unlimited number of queries and reports.

5. Two interactive CD-ROM products have been prepared in conjunction with the fall 2002 survey program. The first is the **Congestion** slide show; this product presents the findings of this report, plus many highlight aerial photographs of congestion. This product can be projected to audiences “as is”; the interactive feature allows a presenter to respond to audience interests by going to specific locations as they come up in the discussion.

The second slide show, the **Photolog** slide show, contains overlapping photographic coverage of all surveyed highways. Using actual survey photographs, Skycomp selected one pass of each surveyed highway and assembled them into this executable slide show. These photographs were not selected to depict congestion; they are provided for infrastructure purposes.

DISCLAIMER

The contents in this publication reflect the views of the author(s), who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Georgia Department of Transportation or the Federal Highway Administration. This publication does not constitute a standard, specification or regulation.

QUESTIONS

If there are any questions about this survey program or the underlying methodology, please direct them to Jasper Craig or Ken Stanek at 410-884-6900.

- **FREEWAY LEVEL-OF-SERVICE RATINGS**
- **ARTERIAL LEVEL-OF-SERVICE RATINGS**

FREEWAY LEVEL-OF-SERVICE RATINGS (UNINTERRUPTED-FLOW FACILITIES):

(NOTE: LEVEL-OF-SERVICE RATINGS ARE BASED ON AVERAGE DENSITIES BETWEEN INTERCHANGES, WHICH ARE GENERALLY GREATER THAN ONE MILE APART. THE EFFECTS OF INCIDENTS AND TEMPORARY ROADWORK HAVE BEEN REMOVED FROM ALL RATINGS BEFORE AVERAGING.)

Level-of-service A: Free-flow speeds; almost completely unimpeded in ability to manueuver.

Level-of-service B: Free-flow speeds; ability to maneuver slightly restricted.

Level-of-service C: At or near free flow speeds; freedom to maneuver is noticeably restricted

Level-of-service D: Speeds begin to decline slightly; freedom to maneuver is more noticeably limited.

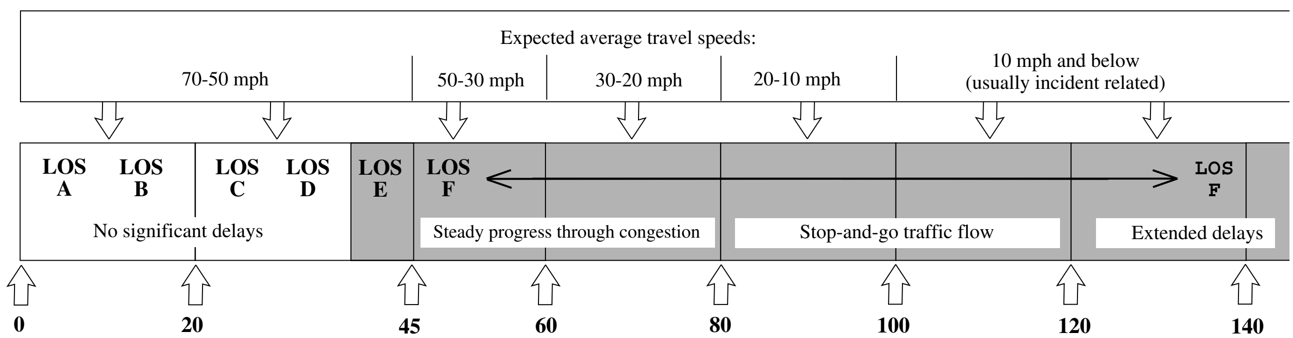
Level-of-service E: Operation at capacity; operations volatile; maneuverability is extremely limited; speeds typically between 60 and 40 mph.

Level-of-service F: Congested traffic flow, with speeds that can range from below 5 mph almost up to 60 mph. For this reason, all "F" ratings have been augmented with average density values, which provide greater insight into the nature of the traffic flow (units are passenger cars per lane-mile):

> **Densities from 46 to 60**: "level-of-service "F" traffic flow averaging approximately 50-30 mph;
>
> **Densities from 60 to 80**: "slow-then-go" traffic flow (some stopping can occur); traffic flow averaging approximately 40-15 mph;
>
> **Densities from 80 to 100**: typically associated with "stop-and-go" traffic flow; average travel speeds approximately 25-10 mph. This is the upper boundary that daily congestion is normally measured at.
>
> *(Densities above 100 for the full length of a segment usually indicate the presence of an incident or construction.)*
>
> **Densities from 100 to 120**: Average travel speeds typically between 15 and 5 mph. In rare cases, daily congestion can be measured at this level, especially for short bottleneck segments.
>
> **Densities from 120 to 180**: severe congestion associated with incidents or construction (180 is the highest density measured by Skycomp, with a corresponding average travel speed below 5 mph).

(For more information, refer to "Procedures for determining freeway level-of-service" in Appendix A. These service level definitions are based on the 2000 Highway Capacity Manual.)

SUMMARY OF FREEWAY TRAFFIC QUALITY RATINGS
(DENSITY-BASED LEVEL-OF-SERVICE)



DENSITY (passenger cars per lane per mile)

These service level definitions are based on the 2000 Highway Capacity Manual

ARTERIAL HIGHWAY TRAFFIC QUALITY RATINGS (INTERRUPTED-FLOW FACILITIES)*:

(NOTE: THESE DESCRIPTIONS APPLY TO TRAVEL ALONG HIGHWAY SEGMENTS, WHICH ARE GENERALLY GREATER THAN ONE MILE IN LENGTH; CONGESTED INTERSECTIONS WITHIN EACH SEGMENT ARE REPORTED SEPARATELY. THE EFFECTS OF INCIDENTS AND TEMPORARY ROADWORK HAVE BEEN REMOVED FROM ALL RATINGS BEFORE AVERAGING.)

Arterial quality level A: Very light traffic flow; few cars using the roadway.

Arterial quality level B: Light traffic flow; little or no platooning.

Arterial quality level C: Moderate traffic flow; platoon populations under 15 vehicles per lane.

Arterial quality level D: Heavy traffic flow; queuing at signals, but all should clear on green (less than 20 vehicles per lane); platoon populations between 15 and 25 vehicles per lane.

Arterial quality level E: Congested traffic flow; large queues (20-40 vehicles per lane) at one or two intersections; slow-moving platoons of greater than 25 vehicles per lane (if one lane, resembles a funeral procession). Also may designate intermittent "F" congestion.

Arterial quality level F: Severely congested traffic flow, usually exhibiting either: 1) traffic backing through upstream signal(s); 2) a series of intersections with large queues (20-40 vehicles per lane); or 3) greater than 40 vehicles per lane queued at one intersection.

* (While these are not arterial level-of-service ratings, they are consistent with the qualitative descriptions of each service level as described in the 2000 Highway Capacity Manual. They do not represent travel time measurements, however, which are the basis for calculating arterial service level ratings.)

(For more information, refer to "Procedures for determining arterial highway traffic conditions" in Appendix A.)

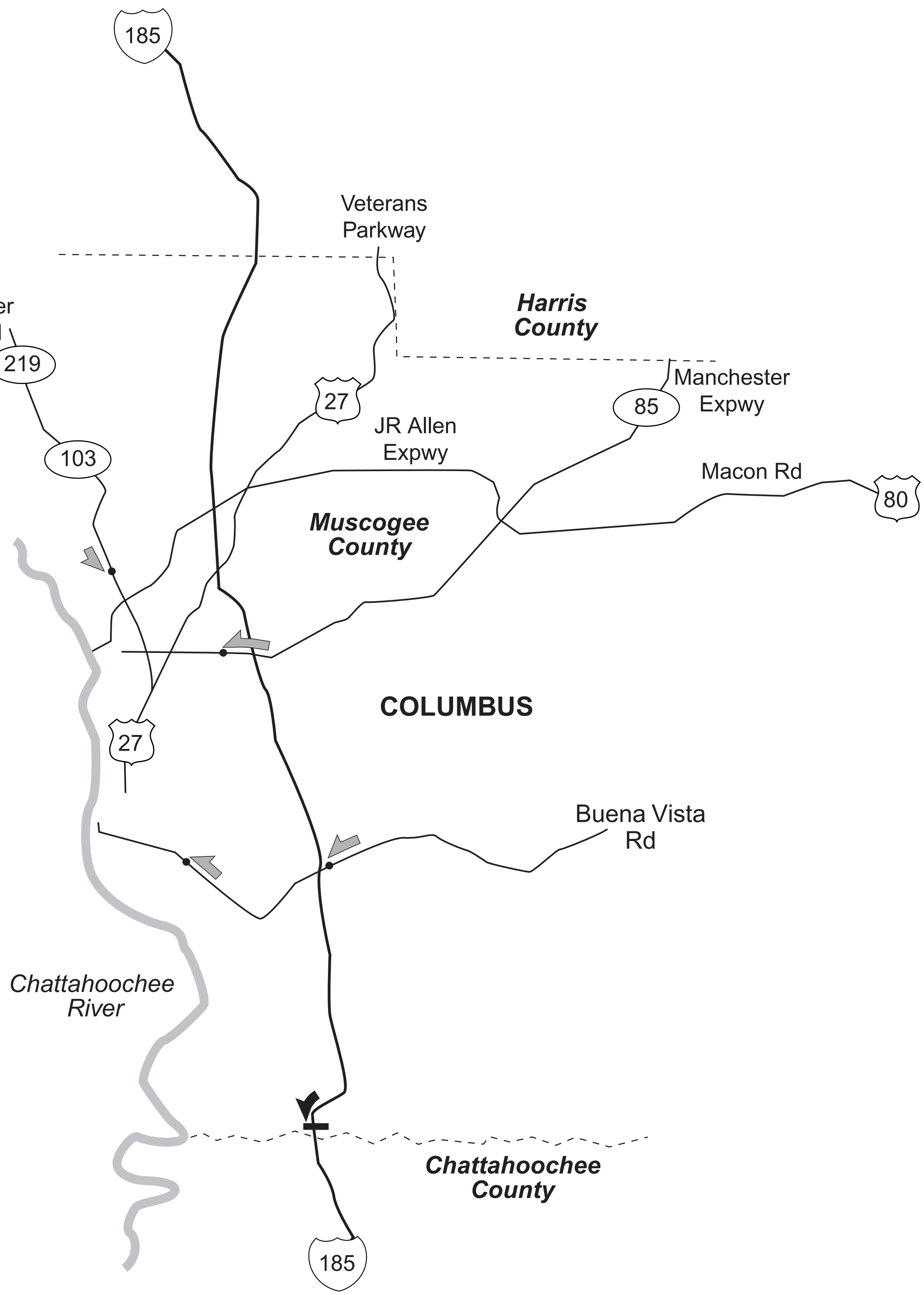
SUMMARY OF ARTERIAL HIGHWAY TRAFFIC CONDITION RATINGS (SURROGATE LEVEL-OF-SERVICE)

Performance ratings on interrupted-flow segments which are generally 1 to 3 miles in length:					
A	**B**	**C**	**D**	**E**	**F**
Very light traffic; few cars on road.	Light traffic; little or no platooning.	Moderate traffic; platoons less than 15 veh. per lane.	Heavy traffic; platoons between 15 and 25 veh. per lane. Significant queuing at signals	Congested traffic; platoons more than 25 veh. per lane; large queues at 1 or 2 intersections.	Severely congested traffic; queuing thru upstream signal(s); series of congested intersections.

(Surrogate level-of-service ratings (underlined) are not travel-time based; however, they are consistent with the qualitative descriptions of traffic flow at each service level in the 2000 Highway Capacity Manual.)

Rating system developed by SKYCOMP, Inc. Columbia MD,
for use with overlapping aerial photographs of highway segments.

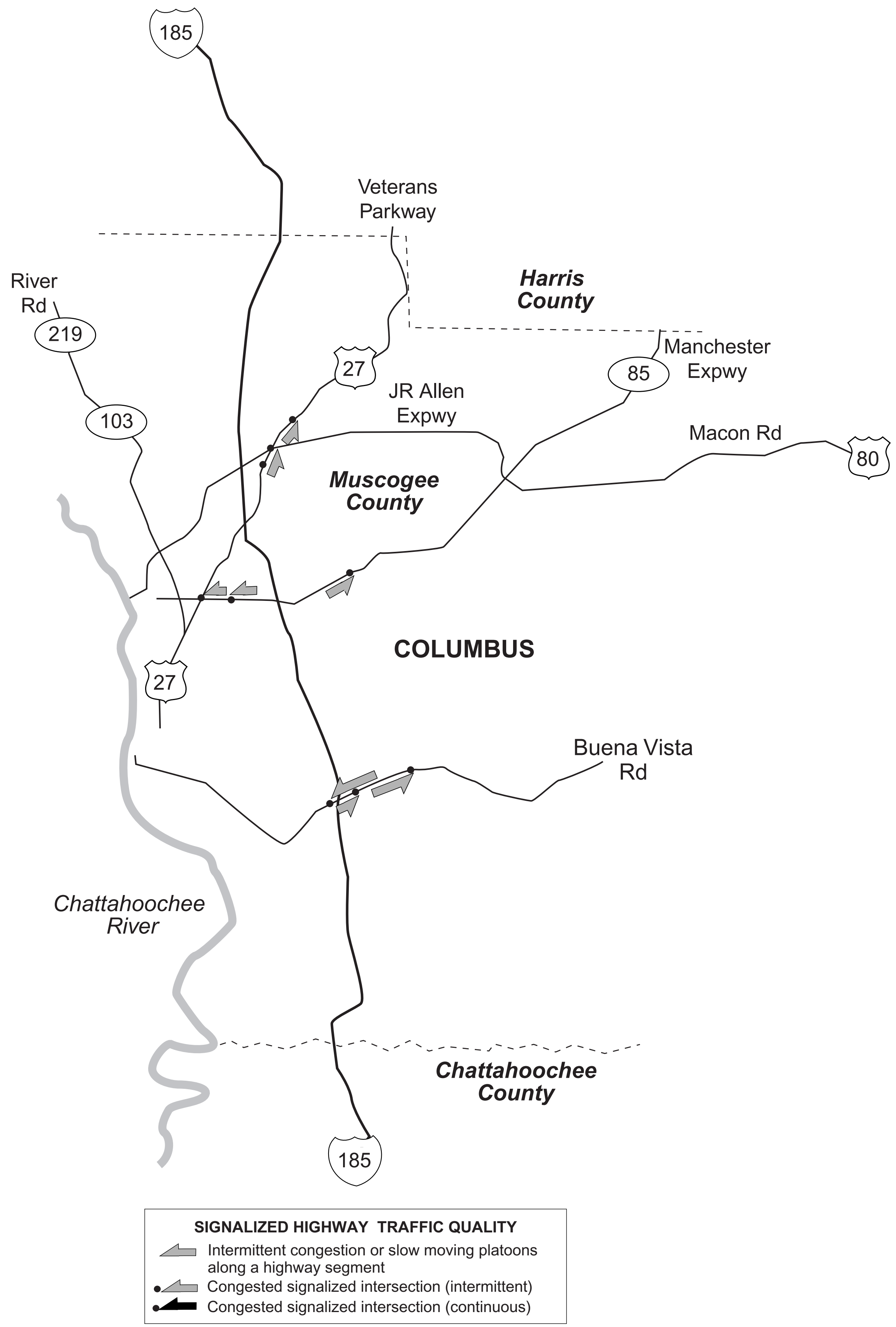
COLUMBUS, GEORGIA
LOCATIONS WHERE CONGESTION WAS FOUND
MORNING



SIGNALIZED HIGHWAY TRAFFIC QUALITY

- Intermittent congestion or slow moving platoons along a highway segment
- Congested signalized intersection (intermittent)
- Congested signalized intersection (continuous)

COLUMBUS, GEORGIA
LOCATIONS WHERE CONGESTION WAS FOUND
EVENING



SURVEYED HIGHWAYS

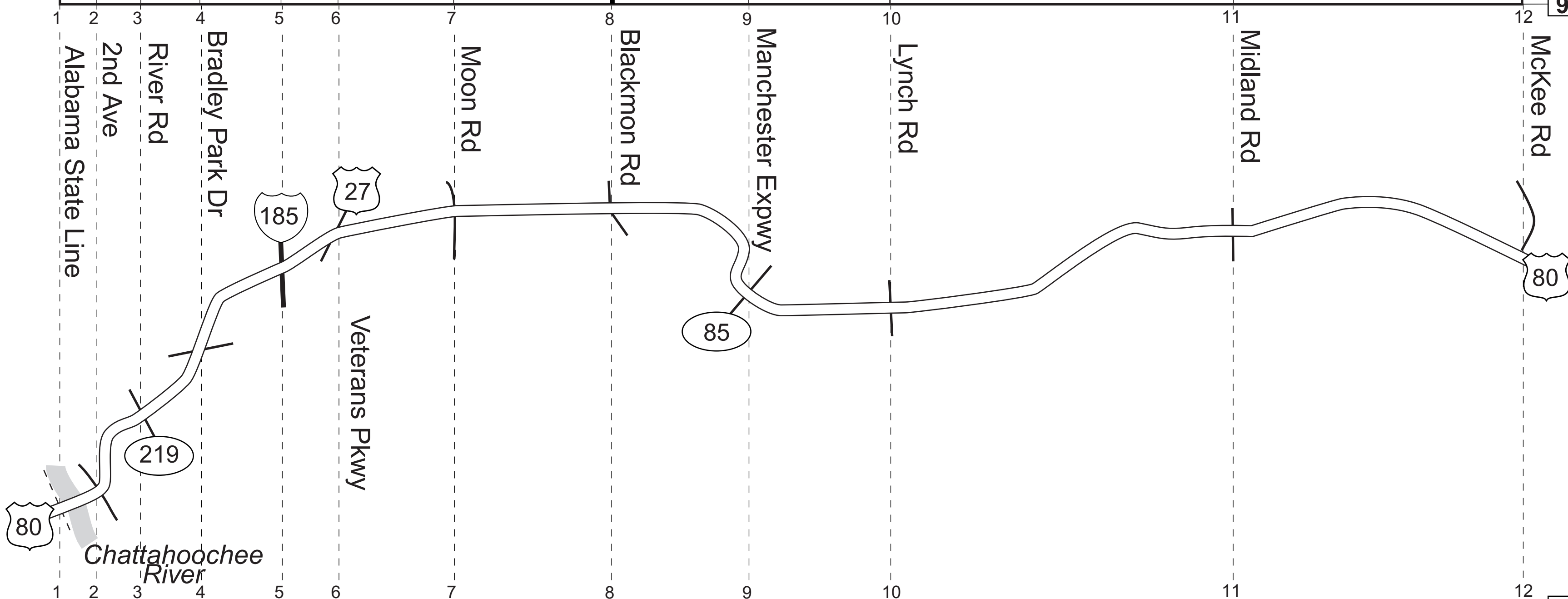
- US 80 (JR Allen Parkway / Macon Rd)
- I-185
- Buena Vista Rd
- Manchester Expressway (SR 85)
- River Rd (SR 103 / 219)
- Veterans Parkway

US 80 (JR ALLEN PARKWAY / MACON RD)

(MORNING - FALL 2002)

WESTBOUND ←

7:00 a.m.	A	B	B	B	A	A	A	C	C	C	C
7:30 a.m.	A	B	B	B	A	A	B	D	C	C	B
8:00 a.m.	A	B	B	A	A	B	B	C	C	C	C
8:30 a.m.	A	B	A	A	A	A	A	C	C	B	B
9:00 a.m.											



7:00 a.m.	C	B	B	A	A	A	A	C	C	B	A
7:30 a.m.	C	B	C	A	A	A	A	D	D	B	B
8:00 a.m.	C	B	B	A	A	A	A	C	C	C	B
8:30 a.m.	A	B	A	A	A	A	A	C	C	B	B
9:00 a.m.											

EASTBOUND →

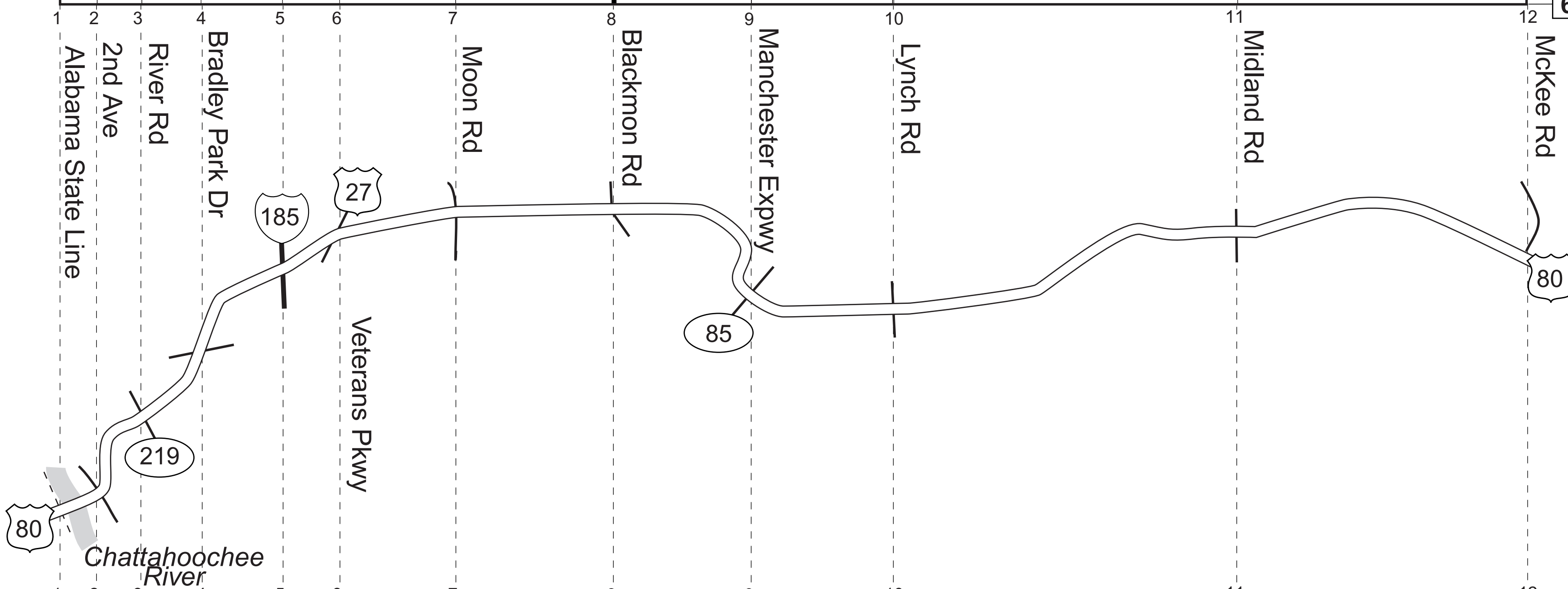
Only minor congestion was found on the US 80 corridor during the morning survey period.

US 80 (JR ALLEN PARKWAY / MACON RD)

(EVENING - FALL 2002)

WESTBOUND ←

	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12
4:00 p.m.	B	B	A	A	A	A	A	C	C	B	A
4:30 p.m.	C	B	B	A	A	A	A	C	C	C	B
5:00 p.m.	D	C	C	A	A	A	A	C	C	B	B
5:30 p.m.	C	C	B	A	A	A	A	C	C	B	B
6:00 p.m.											



	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12
4:00 p.m.	A	A	A	A	A	A	A	C	C	B	B
4:30 p.m.	B	B	B	A	A	A	A	C	C	C	B
5:00 p.m.	B	C	C	B	A	A	A	C	C	C	C
5:30 p.m.	B	B	B	A	A	A	A	C	C	C	B
6:00 p.m.											

EASTBOUND →

Only minor congestion was found on the US 80 corridor during the evening survey period.

I -185

(MORNING - FALL 2002)

SOUTHBOUND

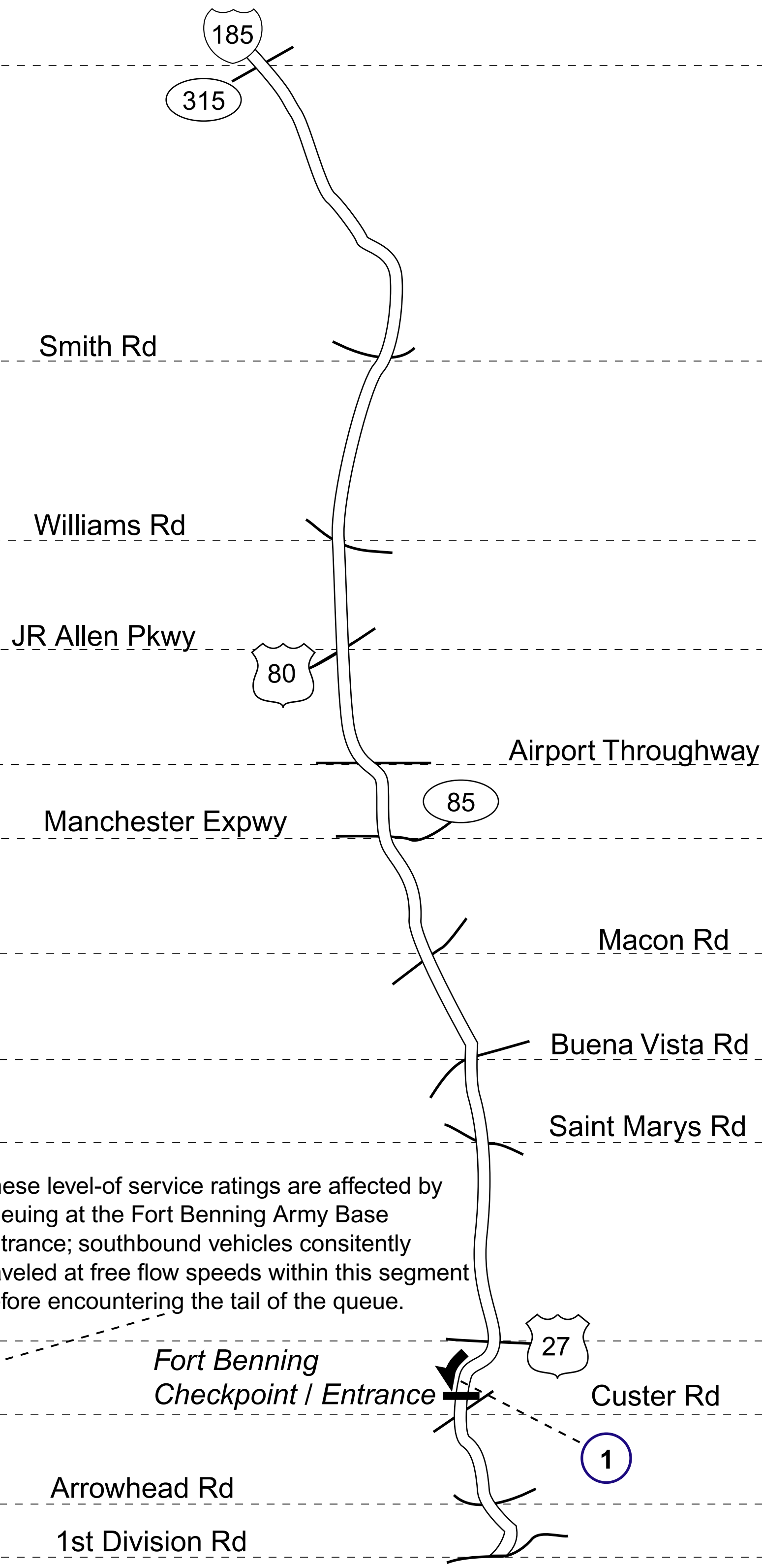
	7:00 a.m.	7:30 a.m.	8:00 a.m.	8:30 a.m.
13–12	A	A	A	A
12–11	A	A	A	A
11–10	A	A	A	A
10–9	A	A	A	A
9–8	A	A	B	A
8–7	B	B	B	A
7–6	B	B	A	A
6–5	B	B	A	B
5–4	B	B	B	B
4–3	F 55	F 50	D	D
3–2		A	A	A
2–1		A		A

(9:00 a.m.)

NORTHBOUND

	7:00 a.m.	7:30 a.m.	8:00 a.m.	8:30 a.m.
13–12	A	A	A	A
12–11	A	A	A	A
11–10	A	A	A	A
10–9	A	A	A	A
9–8	A	A	A	A
8–7	A	B	B	A
7–6	A	B	B	B
6–5	A	A	A	A
5–4	A	A	A	A
4–3	A	A	A	A
3–2		A	A	A
2–1		A		A

(9:00 a.m.)



These level-of-service ratings are affected by queuing at the Fort Benning Army Base entrance; southbound vehicles consitently traveled at free flow speeds within this segment before encountering the tail of the queue.

* Data not available during these time periods due to airspace restrictions at Fort Benning Army Base.

1 Throughout the morning survey period, southbound congestion was found on I-185 approaching the entrance to Fort Benning Army Base. Between 7:00 and 8:00 a.m., queue populations ranged from 45 to 60 vehicles per lane (two lanes); between 8:00 and 9:00 a.m., queue populations ranged from 25 to 40 vehicles per lane.

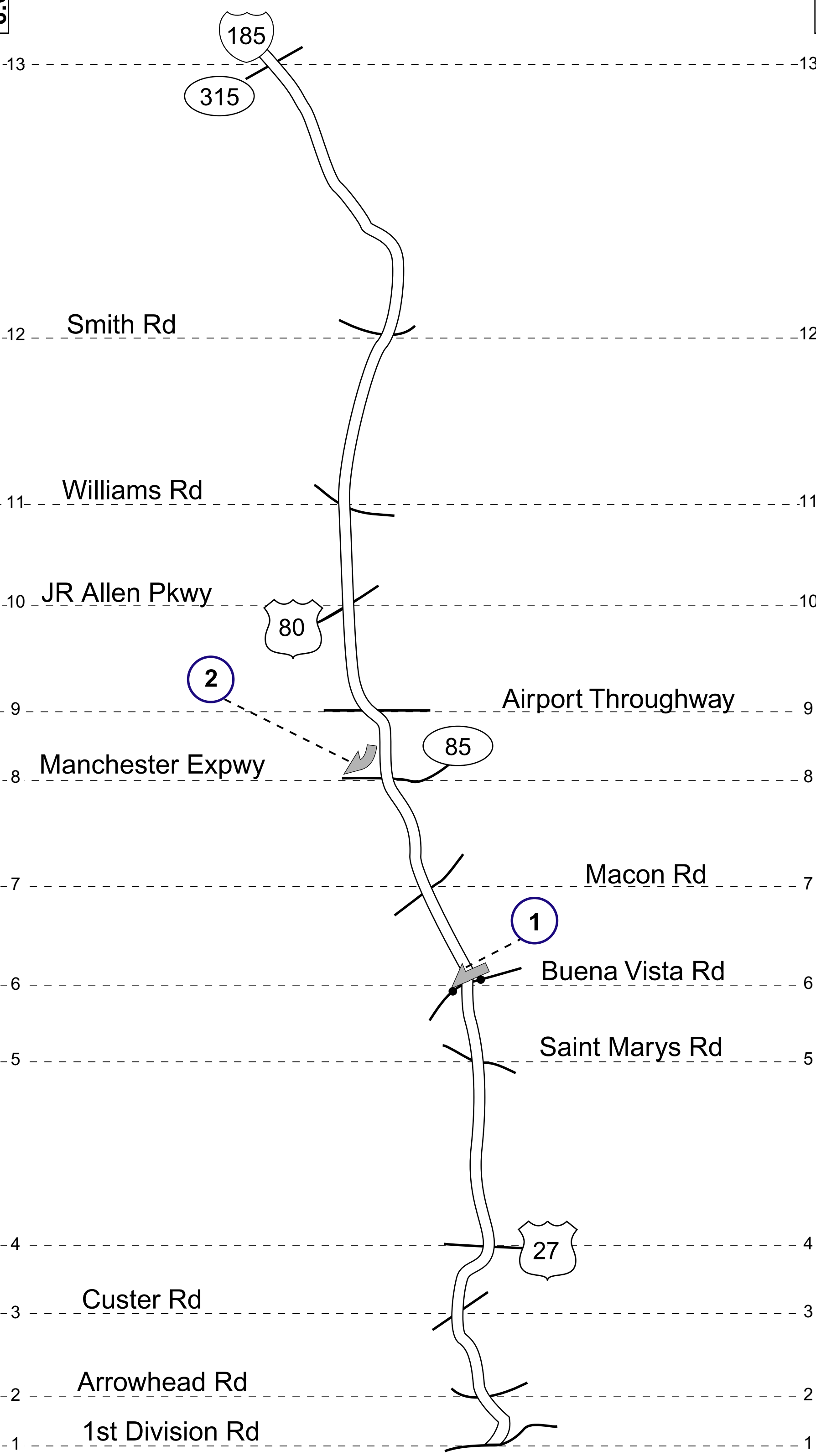
* Data not available during these time periods due to airspace restrictions at Fort Benning Army Base.

I -185

(EVENING - FALL 2002)

SOUTHBOUND

Milepost	4:00 p.m.–4:30 p.m.	4:30 p.m.–5:00 p.m.	5:00 p.m.–5:30 p.m.	5:30 p.m.–6:00 p.m.
13–12	A	A	A	A
12–11	A	A	A	A
11–10	A	A	A	A
10–9	A	A	A	A
9–8	A	A	A	A
8–7	B	A	B	B
7–6	A	A	B	A
6–5	A	A	B	B
5–4	A	A	B	A
4–3	A	B	A	B
3–2	A	A	A	A
2–1	A	A	A	A



NORTHBOUND

Milepost	4:00 p.m.–4:30 p.m.	4:30 p.m.–5:00 p.m.	5:00 p.m.–5:30 p.m.	5:30 p.m.–6:00 p.m.
13–12	A	A	A	A
12–11	A	A	A	A
11–10	A	A	A	A
10–9	B	A	B	A
9–8	B	B	C	B
8–7	C	B	C	B
7–6	B	B	B	B
6–5	A	B	B	B
5–4	C	C	B	B
4–3	C	B	C	A
3–2	B	A	B	A
2–1	A	A	B	A

1. During one observation at 5:51 p.m., westbound congestion was found on Buena Vista Rd approaching the signal at the I-185 southbound ramp; vehicles were queued on the overpass in the two left-turn lanes. This queue extended back through the signal at the northbound ramp, and into the left lane of Buena Vista Rd.

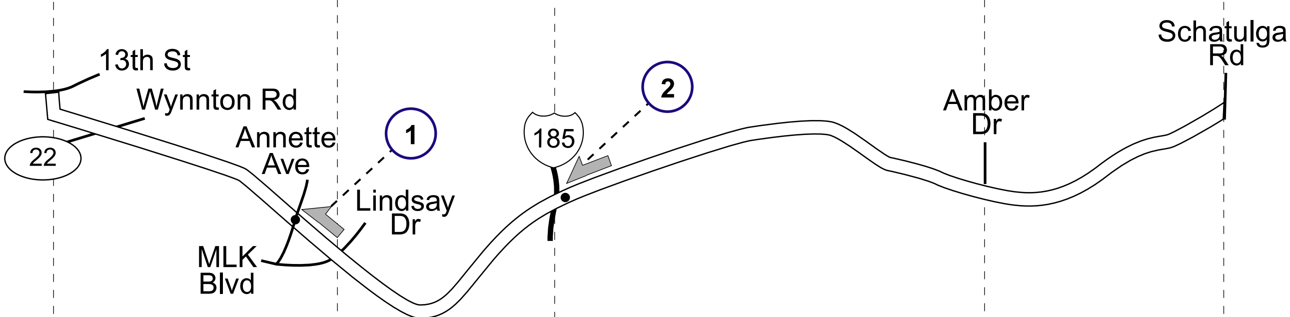
2. Intermittently, congestion was found on the southbound exit ramp at Manchester Expwy; when congested, signal queue populations ranged from approximately 20 to 30 vehicles per lane (two left-turn lanes).

BUENA VISTA RD

(MORNING - FALL 2002)

WESTBOUND ←

	1 – 2	2 – 3	3 – 4	4 – 5
7:00 a.m.	C	C	C	C
7:30 a.m.	D	C	E	C
8:00 a.m.	E	D	E	C
8:30 a.m.	E	D	D	C
9:00 a.m.				



	1 – 2	2 – 3	3 – 4	4 – 5
7:00 a.m.	C	C	C	B
7:30 a.m.	C	C	C	B
8:00 a.m.	D	C	C	C
8:30 a.m.	C	C	C	B
9:00 a.m.				

EASTBOUND →

(1) Intermittently, westbound congestion was found on Buena Vista Rd approaching the signal at Annette Ave; when congested, queue populations ranged from approximately 20 to 25 vehicles (one lane).

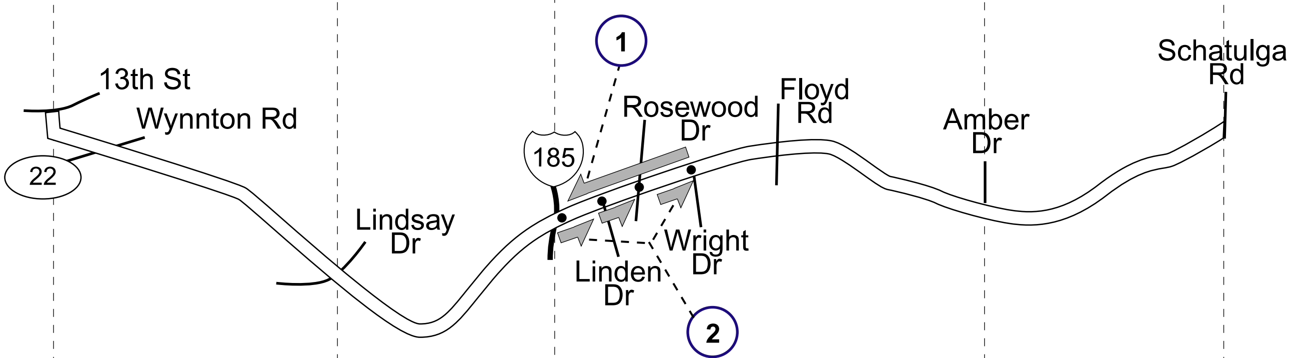
(2) Intermittently, westbound congestion was found on Buena Vista Rd approaching the signal at I-185; when congested, queue populations ranged from approximately 20 to 30 vehicles per lane (two lanes).

BUENA VISTA RD

(EVENING - FALL 2002)

WESTBOUND ←

	1–2	2–3	3–4	4–5
4:00 p.m.	C	D	D	B
4:30 p.m.	C	C	C	B
5:00 p.m.	C	C	D	B
5:30 p.m.	C	C	E	B
6:00 p.m.				



	1–2	2–3	3–4	4–5
4:00 p.m.	D	C	D	B
4:30 p.m.	D	C	D	B
5:00 p.m.	C	D	D	B
5:30 p.m.	C	D	E	B
6:00 p.m.				

EASTBOUND →

(1) Throughout the evening survey period, heavy westbound traffic flow was found on Buena Vista Rd approaching I-185. While the signals at Rosewood Dr, Linden Dr and I-185 caused intermittent congestion, it appeared that westbound travelers typically cleared these signals without experiencing major delay. However, during one observation at 5:43 p.m., significant queuing was found at Rosewood Dr and Linden Dr (queue populations ranged from approximately 25 to 50 vehicles per lane).

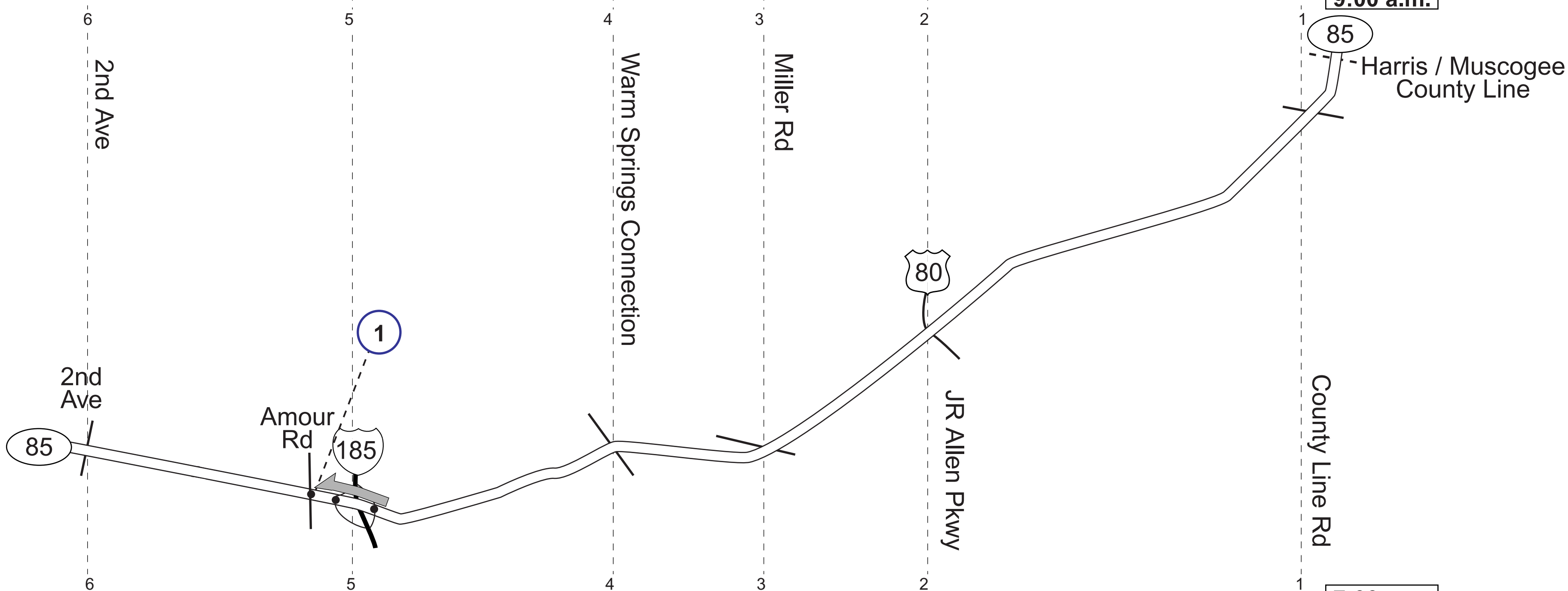
(2) After 5:00 p.m., eastbound congestion was found on Buena Vista Rd between I-185 and Floyd Rd; the primary bottlenecks were found at the signals at Linden Dr, Rosewood Dr and Wright Dr. When congested, queue populations ranged from approximatley 20 to 30 vehicles per lane (two lanes).

MANCHESTER EXPRESSWAY / SR 85

(MORNING - FALL 2002)

← WESTBOUND

	6–5	5–4	4–3	3–2	2–1
7:00 a.m. – 7:30 a.m.	C	C	A	A	A
7:30 a.m. – 8:00 a.m.	C	D	B	A	A
8:00 a.m. – 8:30 a.m.	E	D	A	A	A
8:30 a.m. – 9:00 a.m.	D	C	A	A	A



	6–5	5–4	4–3	3–2	2–1
7:00 a.m. – 7:30 a.m.	C	C	A	A	A
7:30 a.m. – 8:00 a.m.	C	C	A	A	A
8:00 a.m. – 8:30 a.m.	C	C	A	A	A
8:30 a.m. – 9:00 a.m.	C	C	A	A	A

EASTBOUND →

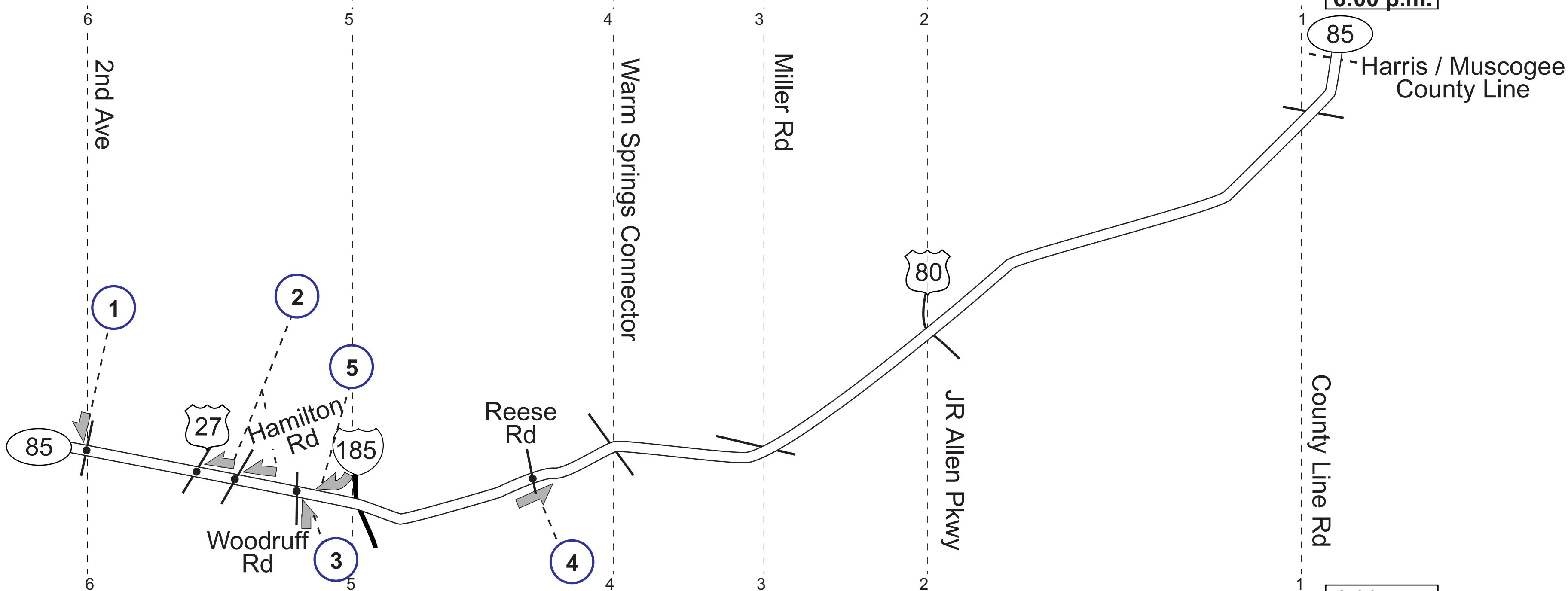
1 Intermittently, westbound congestion was found on Manchester Expressway (SR 85) in the vicinity of I-185; congestion appeared to be generated by the pair of signals at the I-185 interchange, and the downstream signal at Amour Rd.

MANCHESTER EXPRESSWAY / SR 85

(EVENING - FALL 2002)

← WESTBOUND

6–5	5–4	4–3	3–2	2–1	
C	C	A	A	A	4:00 p.m.
C	C	A	A	A	4:30 p.m.
D	C	A	A	A	5:00 p.m.
E	C	A	A	A	5:30 p.m.
					6:00 p.m.



6–5	5–4	4–3	3–2	2–1	
C	C	B	A	A	4:00 p.m.
D	C	A	A	A	4:30 p.m.
D	C	B	A	A	5:00 p.m.
C	E	A	A	A	5:30 p.m.
					6:00 p.m.

EASTBOUND →

MANCHESTER EXPRESSWAY / SR 85

(EVENING - FALL 2002)

1 Intermittently, southbound congestion was found on 2nd Ave approaching the signal at Manchester Expressway (SR 85); when congested, approximately 20 vehicles were queued in the left-turn lane.

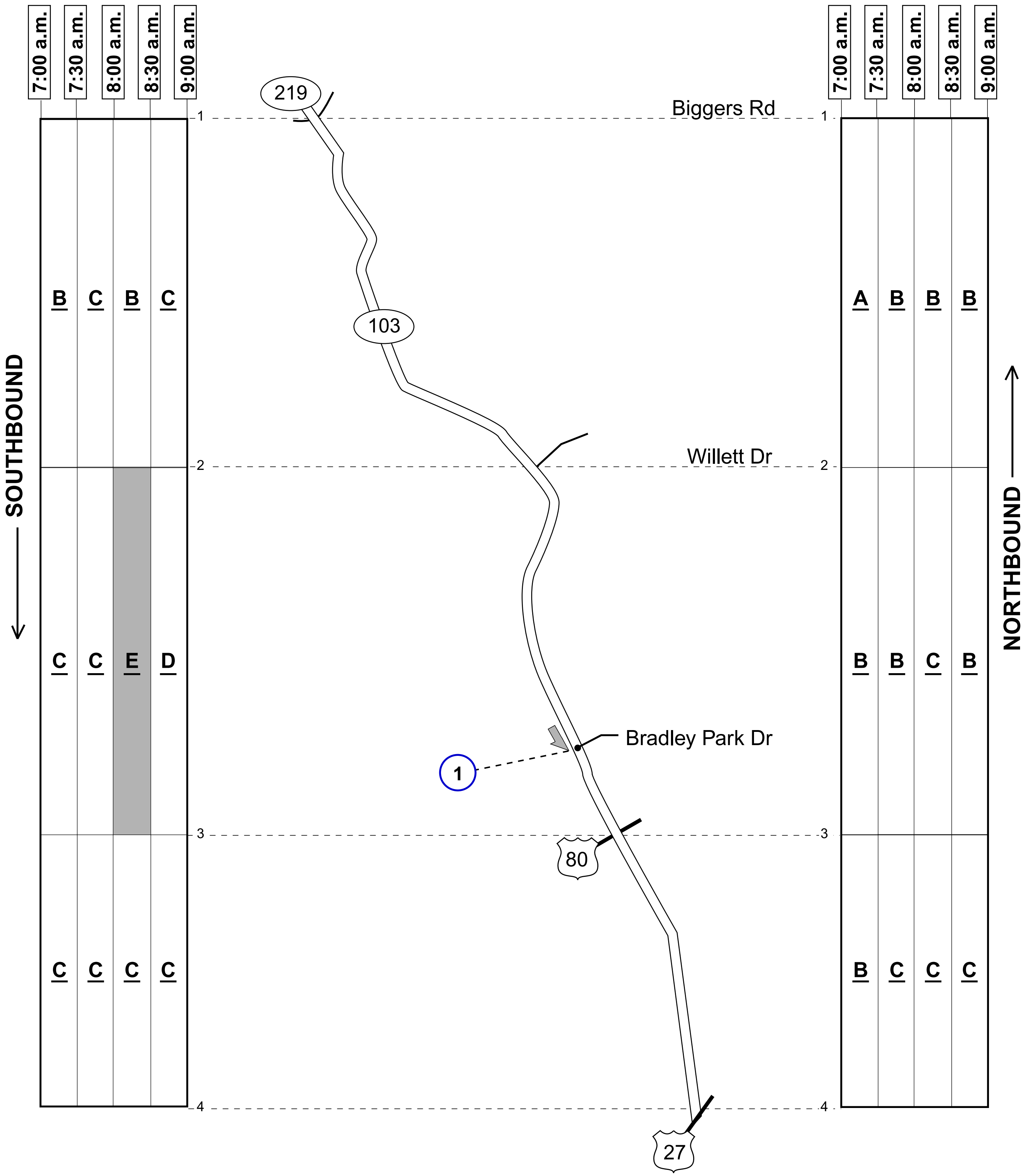
2 After 5:00 p.m., intermittent westbound congestion was found on Manchester Expressway (SR 85) approaching the pair of closely spaced signals at Hamilton Rd and US 27 (Veterans Parkway); when congested queue populations ranged from approximately 20 to 30 vehicles per lane (two lanes).

3 Intermittently, northbound congestion was found on Woodruff Rd approaching the signal at Manchester Expressway (SR 85); when congested, the queue contained approximately 20 vehicles per lane (two lanes).

4 During several observations after 5:30 p.m., large platoons were found traveling eastbound through the signal at Reese Rd; platoon populations ranged from approximately 25 to 30 vehicles per lane (two lanes).

5 Intermittently, congestion was found on the I-185 southbound exit ramp at Manchester Expwy; when congested, signal queue populations ranged from approximately 20 to 30 vehicles per lane (two left-turn lanes).

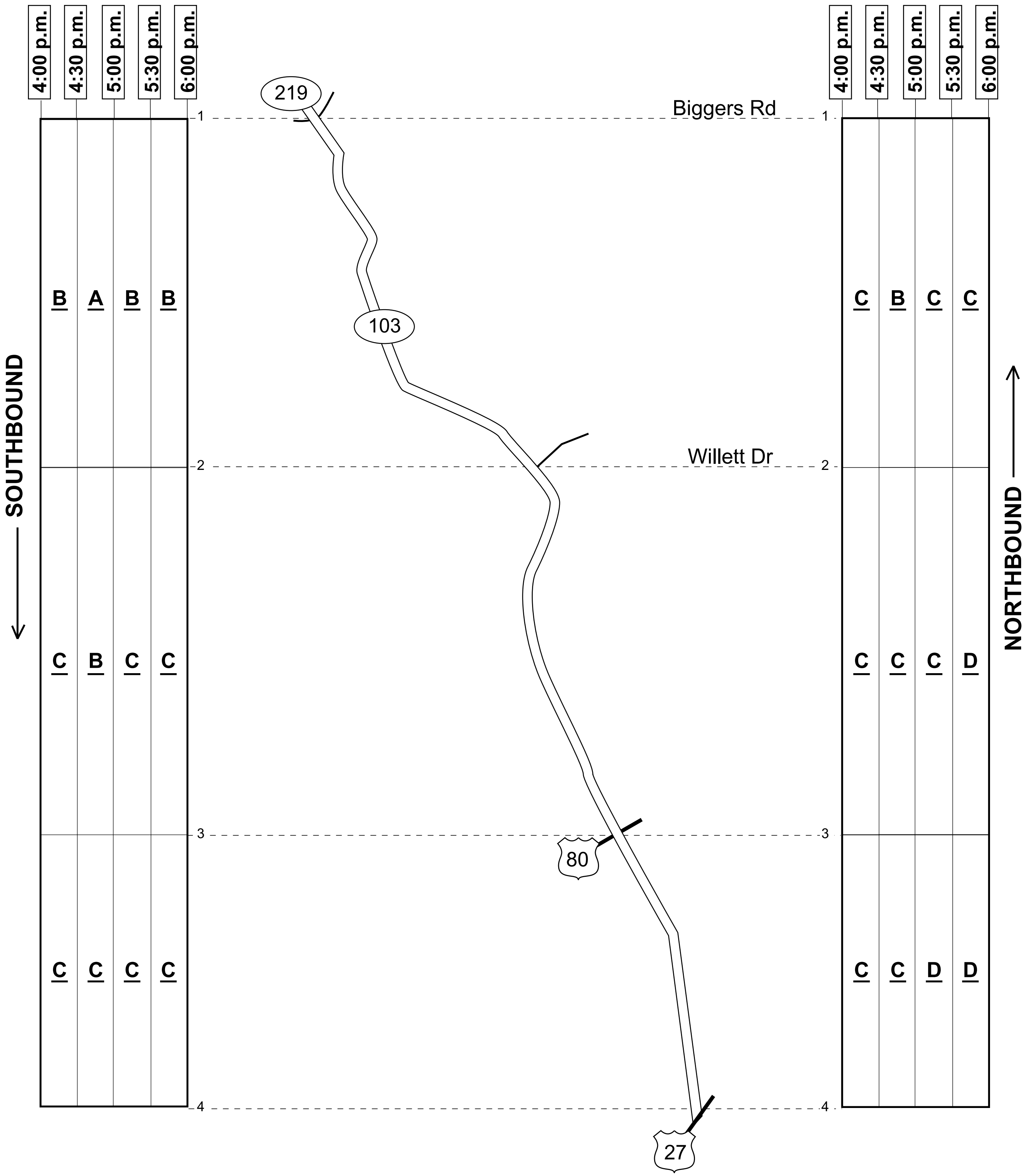
RIVER RD (SR 103 / 219)
(MORNING - FALL 2002)



1 Between 8:00 and 8:30 a.m., intermittent southbound congestion was found on River Rd approaching the signal at Bradley Park Dr; when congested, queue populations ranged from approximately 20 to 25 vehicles (one lane).

RIVER RD (SR 103 / 219)

(EVENING - FALL 2002)



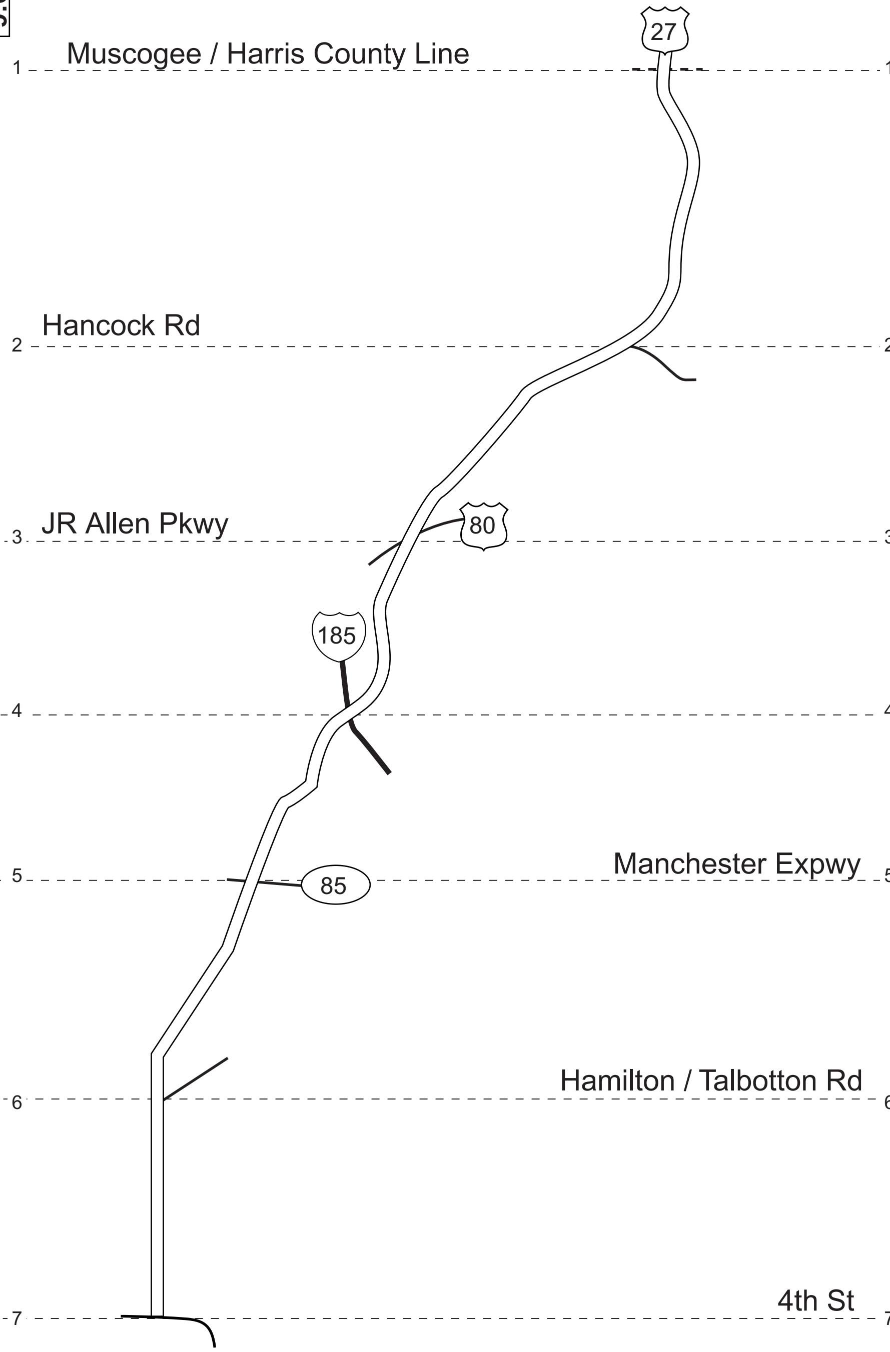
Only minor congestion was found on River Rd
during the evening survey period.

VETERANS PARKWAY (US 27)

(MORNING - FALL 2002)

SOUTHBOUND

Segment	7:00 a.m.	7:30 a.m.	8:00 a.m.	8:30 a.m.	9:00 a.m.
1–2	B	C	D	B	
2–3	C	D	C	C	
3–4	C	C	C	C	
4–5	C	C	D	C	
5–6	C	C	C	C	
6–7	C	C	C	C	



NORTHBOUND

Segment	7:00 a.m.	7:30 a.m.	8:00 a.m.	8:30 a.m.	9:00 a.m.
1–2	B	C	B	B	
2–3	C	C	C	C	
3–4	C	C	C	C	
4–5	C	C	C	C	
5–6	C	C	C	C	
6–7	C	C	C	C	

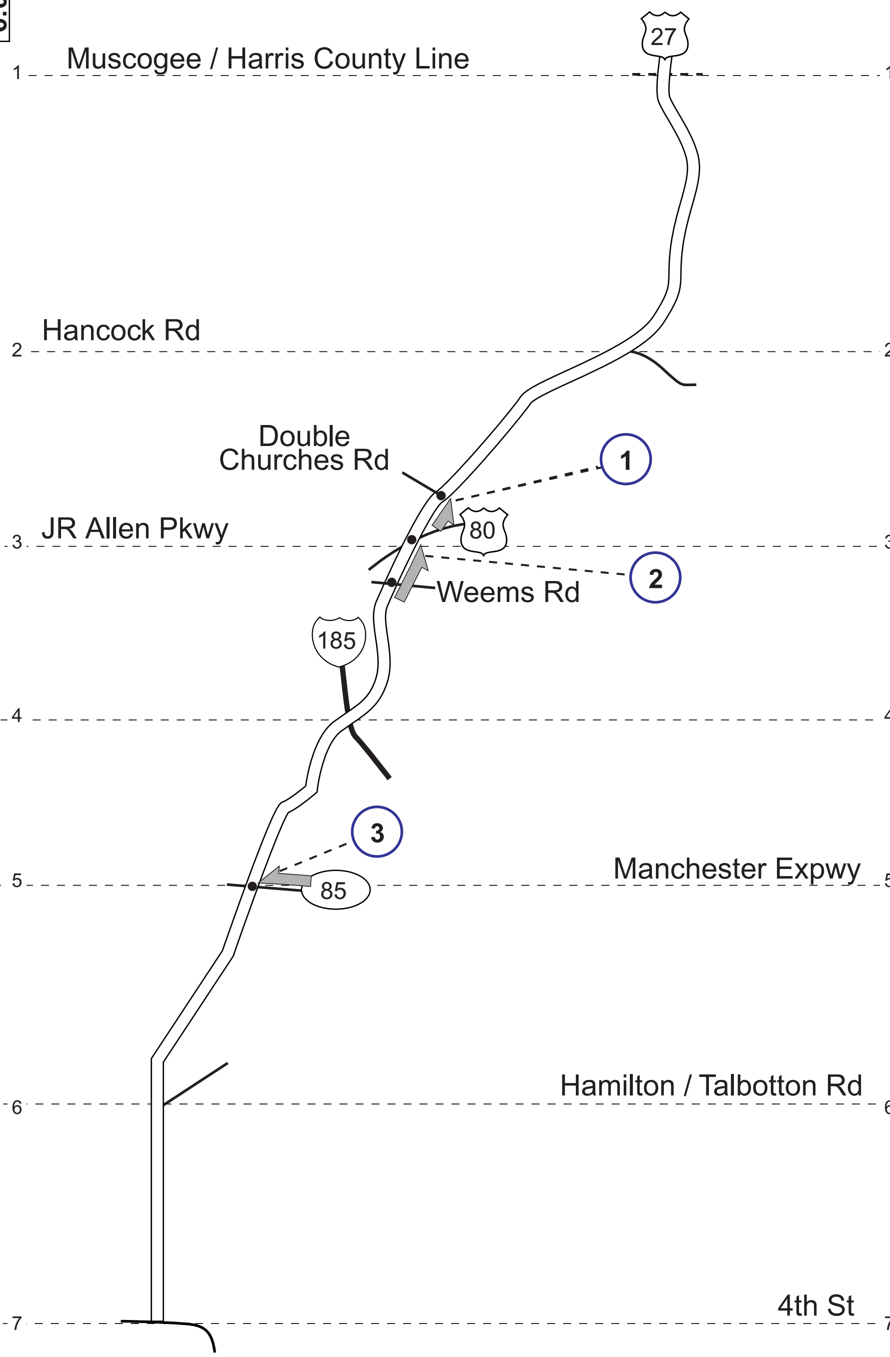
Only minor congestion was found on Veterans Parkway (US 27) during the morning survey period.

VETERANS PARKWAY (US 27)

(EVENING - FALL 2002)

SOUTHBOUND ⟵

	4:00 p.m.	4:30 p.m.	5:00 p.m.	5:30 p.m.	6:00 p.m.
1–2	B	B	B	B	
2–3	C	C	D	C	
3–4	C	C	C	C	
4–5	C	C	C	C	
5–6	C	C	C	C	
6–7	C	C	C	C	



NORTHBOUND ⟶

	4:00 p.m.	4:30 p.m.	5:00 p.m.	5:30 p.m.	6:00 p.m.
1–2	B	C	C	C	
2–3	D	C	D	D	
3–4	C	D	E	C	
4–5	D	D	D	D	
5–6	C	C	D	C	
6–7	C	C	C	C	

1. Intermittently, northbound congestion was found on Veterans Parkway approaching the signal at Double Churches Rd; when congested, approximately 20 to 30 vehicles were queued in the left-turn lane.

2. Intermittently, heavy northbound traffic flow was found on Veterans Parkway traveling through the series of signals between Weems Rd and US 80; while no one signal appeared to generate large queue populations, delays were apparent for northbound travelers.

3. After 5:00 p.m., intermittent westbound congestion was found on Manchester Expressway (SR 85) approaching the signal at Veterans Parkway (US 27); when congested queue populations ranged from approximately 20 to 30 vehicles per lane (two lanes).

APPENDIX A

PROCEDURES FOR DETERMINING FREEWAY LEVEL-OF-SERVICE

METHODOLOGY DESCRIPTION

PERFORMANCE MEASURE: DENSITY-BASED LEVEL OF SERVICE

According to the *2000 Highway Capacity Manual* (the HCM), the defining parameter of freeway level-of-service is density, measured in units of passenger-cars per lane per mile (pcplpm). While densities are commonly calculated from speed and volume data, another method is to measure densities directly from aerial photographs. This is the approach used in the Savannah survey program.

The LOS rating system uses the letters "A" through "F" to describe traffic conditions: LOS "A" represents superior traffic conditions (very light traffic), while LOS "F" represents poor traffic conditions (congested flow involving various degrees of delay). These letters are assigned based on how densely cars are traveling on the road. Research has shown that for all densities below 40 pcplpm, vehicles generally move at or close to normal highway speed; LOS "A" through "E" represent these densities according to the following table (pcplpm):

LOS "A": densities from **zero to 11**;
LOS "B": densities from **12 to 18**;
LOS "C": densities from **19 to 26**;
LOS "D": densities from **27 to 35**;
LOS "E": densities from **36 to approx. 45**
(Note: In Georgia, outside the Atlanta Metropolitan area, the threshold for congestion is level-of-service "D")

At densities greater than **40**, speeds typically decrease and traveler delays are incurred. Because flow at all densities greater than **46** (approximately) are regarded as LOS "F", this report attaches actual densities to all LOS "F" ratings. Accordingly:

LOS "F":
- Densities from **46 to 60** indicate delay involving minor degrees of slowing; average speeds usually range between 50 and 30 mph;
- Densities from **60 to 80** indicate traffic flow at average speeds usually ranging between 40 and 15 mph;
- Densities from **80 to 100** indicate congested traffic flow, with some stopping possible; average speeds usually range between 10 and 25 mph;
- Densities above **100** indicate severe congestion, with considerable stop-and-go flow likely. For reference, densities above 120 almost always indicate the presence of unusual events (accidents, roadwork, etc.). The practical maximum value for density measurements is **180**; the theoretical maximum value is **264** (at 20 feet per vehicle).

DATA REDUCTION PROCEDURES

From overlapping time-stamped photographs, densities by highway segment were determined by manual counts taken along the entire segment length. Vehicles were classified as cars, trucks, buses, or tractor-trailers when counted; later, passenger-car equivalents (pce's) were derived according to the following table:

Vehicle type:	PCE’s:
cars	1
trucks	1.5
tractor-trailers	2.0
buses	1.5

Data that were atypical due to roadwork or to known or suspected incidents were coded for exclusion from the averaging process. All data were then entered into a microcomputer database program, which performed the following tasks: 1) samples were grouped by time slice; 2) average densities were calculated; and 3) densities were converted into service levels “A” through “F”. The computer then prepared matrices showing each averaged service level rating plotted by time and highway segment. These data matrices were then copied into the traffic quality tables, which are provided in this report.

In the tables, all LOS E and F conditions (congested traffic flow) have been outlined and shaded. Because LOS “F” encompasses a wide range of densities, the actual density values are entered next to the "F"; using the travel characteristics in the density ranges provided above, the nature of the flow in LOS F segments can be determined.

While examining the photography, data technicians also identified side streets and on/off ramps that were congested. Where these problems were recurring, descriptive narratives were prepared.

PROCEDURES FOR DETERMINING ARTERIAL HIGHWAY TRAFFIC CONDITIONS

METHODOLOGY DESCRIPTION

Due to the interrupted nature of traffic flow on signalized highways, density is usually not a preferred performance measure for traffic quality. This is because long segments of roadway often contain few or no vehicles, not for lack of demand, but because vehicles are intermittently held at signalized intersections.

For this and other reasons, the defining parameter for arterial highway level-of-service is travel time over distances of at least one mile in downtown areas and at least two miles in other areas. This measure cannot be obtained efficiently across a large region by a fast-moving airplane.

On the other hand, various levels of traffic conditions can easily be seen from above. Trained aerial observers can clearly and consistently differentiate between highways that are lightly, moderately, and heavily traveled. Furthermore, bottlenecks are easily found from above; the more severe the problem, the better it shows up in aerial photographs.

Thus Skycomp has developed a *qualitative* measure of traffic flow on arterial highways, to be applied through examination of 100% overlapping photographic coverage of each highway segment. This methodology and the accompanying rating scale was developed to satisfy the following objectives:

- the rating scale cover the full range of traffic conditions on arterial highways, from empty to densely congested streets, with reasonable gradations in between;
- the methodology be repeatable such that different persons would generally assign the same ratings when viewing the same photographs;
- the ratings are not sensitive to photographs being taken at various points in the signal cycle;
- for ratings that indicate level-of-service "E" and "F" congestion, descriptive narratives could be attached which qualify the ratings and which designate supporting photography;
- the methodology be reasonably consistent with the descriptions of the six service levels in the 2000 HCM (but without regard to the travel-time criteria, which are the defining parameter).

Because of the last objective, a six-point scale was chosen, also using the letters “A” through “F”. Skycomp’s arterial performance ratings have been underlined in order to designate them as service level surrogates, rather than service level measurements).

Thus the performance rating scale used in this report is defined as follows:

Performance Rating <u>A</u>:
— very few cars using the roadway; or deserted roadway. *[HCM description for LOS A: Vehicles are completely unimpeded in their ability to maneuver within the traffic stream; primarily free-flow operations.]*

Performance Rating <u>B</u>:
— light traffic flow; little or no platooning. *[HCM description for LOS B: reasonably unimpeded operations; ability to maneuver only slightly restricted.]*

Performance Rating <u>C</u>:
— moderate traffic flow; not heavy, not light. Platoon populations not greater than 15 vehicles per lane. *[HCM description for LOS C: stable operations; ability to maneuver may be more restricted than LOS B.]*

Performance Rating <u>D</u>:
— Heavy traffic flow; many cars on the road. Significant queuing at signals, but all should clear on green (less than 20 vehicles per lane queued at all signals). Platoon populations typically between 15 and 25 vehicles per lane. *[HCM description for LOS D: borders on unstable flow where small increases in flow may cause substantial increases in delay and decreases in travel speed.]*

Performance Rating <u>E</u>:
— congested traffic. Segment may contain one or two intersections with queues of more than 20 vehicles per lane (all may not clear on green). Platoon populations greater than 25 vehicles per lane. On long one-lane segments, the movement of vehicles may resemble a funeral procession, with little opportunity for side-traffic to enter the roadway. *[HCM description for LOS E: significant delays and low average travel speeds; typical causes include adverse progression, high signal density, high volumes, extensive delays at critical intersections, and inappropriate signal timing.]*

Performance Rating <u>F</u>:
— severely congested traffic; includes: vehicles backing through an upstream signal, or for the length of the segment; a series of intersections with more than 20 vehicles per lane queued at each; segment containing one severely congested intersection, with more than 40 vehicles per lane queued approaching the signal (may take two or more signal cycles to clear the intersection). *[HCM description for LOS F: flow at extremely low speeds; intersection congestion is likely at critical signalized locations with high delays, high volumes, and extensive queuing.]*

(Note: In Georgia, outside the Atlanta Metropolitan area, the threshold for congestion is level-of-service "D")

The primary evaluator was trained to view each segment in its entirety (lay out photos side-by-side), and start by testing whether a rating of "<u>C</u>" was appropriate for the segment. Working from this "<u>C</u>" rating, the evaluator could then adjust the rating upward or downward as warranted by the conditions.

In the event that an incident or temporary roadwork significantly affected the rating, the evaluator attached a code which would exclude the affected data from averaging with the results of other days.

After a quality-control review by the project manager, all ratings were digitized and entered into a computer database program for evaluation and averaging. Ratings were printed by time slice and by day, so that unusual ratings could be identified. If there were odd results (for example, “B” ratings on three days and an “F” rating on one day), the photography was checked for possible error or incident. If the data were clearly atypical but a cause could not be identified, a code “u” (“unknown”) was attached to the data (like the incident and roadwork codes, this would also exclude the data from averaging).

Data were then averaged, and entered into the level-of-service tables shown in the main body of the report. It should be remembered that these ratings are averages, and thus a location with intermittently severe congestion may get the same rating as locations with steady less-severe congestion.

APPENDIX B

METHODOLOGY DESCRIPTION

Procedures for obtaining speed/density samples for calibration of
the Van Aerde Speed / Density Model

BACKGROUND

In the spring of 1995, Skycomp collected data to compare the speed of vehicles through congested freeway zones with corresponding densities obtained from aerial photographs. The purpose was to explore the relationship between the two, and, given a reasonable correlation, to prepare a model by which vehicle speeds could be estimated from aerial density photographs.

The program was conceived and executed by the Metropolitan Washington (D.C.) Council of Governments (MWCOG). Aerial data were collected by Skycomp; analysis of the data and calibration of the Van Aerde speed/density model were conducted by MWCOG (draft paper included in this appendix).

A secondary objective was to evaluate the accuracy of aerial speed and density measurements by comparing them to data collected by traditional methods (floating cars and loop detectors embedded in the pavement).

Accordingly, segments of freeway were chosen to be surveyed that: 1) were expected to generate congested traffic flow; and 2) either contained a loop detector station or would accommodate quick turnarounds for multiple floating car runs. Thus, while data were being collected in the air (290 speed samples were obtained from the air, along with corresponding densities), loop detector or floating car data were collected concurrently on the ground.

The outcome of this study was a finding that travel speeds across congested freeway segments could be determined with reasonable accuracy using only aerial density photographs. It was also found that speeds and densities obtained through aerial techniques closely matched data obtained using the traditional ground methods.

PROCEDURES TO OBTAIN SPEED / DENSITY SAMPLES:

The observer/photographer followed the following procedure to obtain all speed/density samples: he first flew along the selected survey segment while taking time-stamped overlapping density photographs of the entire segment; next, at the upstream end, he selected a target “floating” car for tracking; he photographed the target as it entered and departed the segment, while simultaneously timing its run to the nearest second. He then took an “after” density photo set; and then recorded the following information on a clipboard: the time of the sample, the target vehicle description, lane(s) traveled, elapsed time, and any special notes. This procedure was repeated for each speed/density data point.

In the actual course of sampling, this procedure was modified in several ways. First, where cars were moving at high (free-flow) speeds, the density did not change significantly between samples; thus sometimes three or more floating cars were timed between density runs.

Another modification done in-flight is as follows: the observer noted in several cases that the density set taken before the target vehicle went through better reflected the conditions the car encountered than the density set taken after the vehicle went through (or vice versa). This was usually due to a delay in changing film, extra maneuvering the airplane, or any other event which delayed the “after” density sample for several minutes after the completion of the run. While normally the density associated with each speed sample was an average of the “before” and “after” density sets, in these cases only the “before” or “after” density set would be used (as directed by the observer).

With regard to selection of target vehicles, the plan was to select cars that reflected the average speed of traffic, just as floating car drivers are instructed to approximate the speed of traffic flow. Fortunately, vehicles have little freedom to choose their speeds in the congested density ranges (above 40 pcplpm). So, for example, almost any vehicle in a congested traffic stream in the middle lane of three will give a suitable floating car measurement. Even tractor-trailers (unless heavily loaded and traveling uphill) moved at the same speed as passenger cars. Thus the criteria the observer used in selecting each target vehicle was 1) is it in the correct lane; and 2) does the vehicle stand out so that it is easy to keep track of?

Also, in the event that the highway had four travel lanes in one direction, alternating samples were taken from both middle lanes.

In the event that a driver switched lanes while being tracked, the observer noted the lane change and also noted which lane the car spent the majority of time in (this is the lane for which a density count would be made later). In several cases (infrequently), the observer abandoned tracking certain vehicles when: 1) the driver made multiple lane changes, trying to beat the average speed of traffic; 2) the driver switched lanes and changed speeds obviously and significantly; 3) the vehicle turned out to be a heavily loaded truck which delayed the traffic stream; or 4) the observer “lost” the vehicle being tracked. Also, for the samples made with traffic traveling at free-flow speeds, vehicles were abandoned which proved to be traveling significantly faster or slower than the average speed of traffic.

In the event that the target vehicle moved to the right lane in apparent preparation to exit, the observer often was able to switch tracking to another vehicle that had been just behind or ahead of the original vehicle in the same lane (and used the newly adopted vehicle to complete the sample). This was necessary because in some cases six or seven minutes had been invested in the tracking of a specific vehicle, and it was important to avoid wasting that time where possible.

It should also be pointed out that speeds were not tracked for very slow moving queues (densities over 120 / MWCOG samples only). Instead, density runs were made at 5 or 10 minute intervals, such that later on the ground the same vehicles could be found in succeeding sets of density photos; this allowed computation of speeds and associated densities.

DATA PROCESSING

After each flight, a topographic map was prepared for each zone which showed the starting and stopping points for each tracked car. Measurements were then made of the segment length (distance traveled). Then each tracked vehicle was entered into the computer database, including:

1. vehicle description
2. time-of-day
3. initial lane and subsequent lane changes
4. precise travel time (from stopwatch or time-lapse photographs)
5. density-photo preference, if any (default was to average the before- and after- density samples)
6. any special notes pertaining to that vehicle.

After the photos had been processed, each set of overlapping "density" photographs was taped together into a "mosaic" that showed each entire segment. Then vehicles in the required lane(s) were counted, listed by "car", "truck", "tractor-trailer" and "bus". These totals were translated into passenger-car equivalents (PCE's) using the following values:

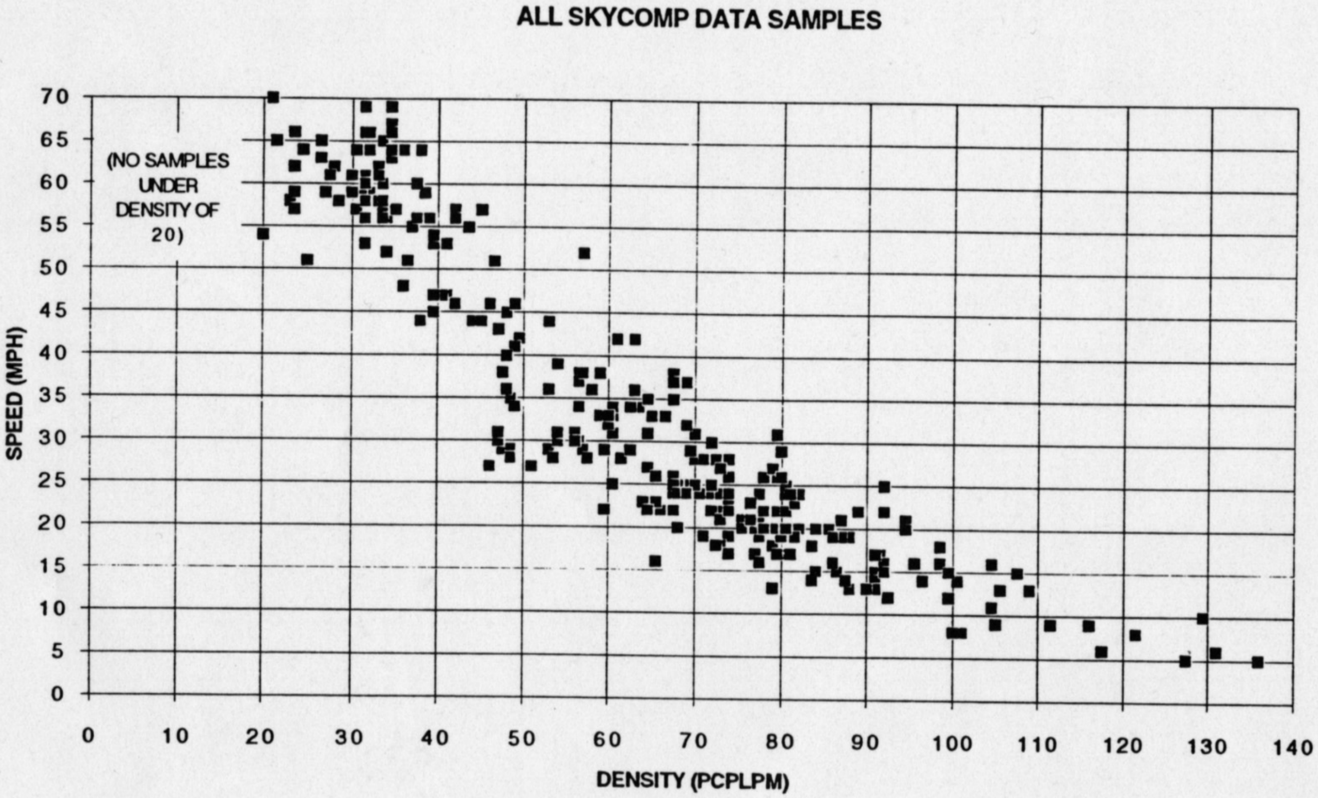
Vehicle type:	PCE's:
cars	1
trucks	1.5
tractor-trailers	2.0
buses	1.5

(It should be noted that the distinction between "cars" and "trucks" could not be cleanly made, since there are many varieties of light and heavy pick-ups (both covered and uncovered). In general, a pick-up or van had to be at least twice the size of an average-sized car to be considered a "truck".)

PCE's were then divided by segment length to calculate densities. These density samples were then matched to corresponding speed samples; each speed/density data pair was then plotted on the chart.

CALIBRATION OF THE VAN AERDE MODEL

The latest draft of the MWCOG paper describing the calibration of the Van Aerde Speed / Density Model for the Washington D.C. metropolitan area is provided next. This paper was authored by Paul DeVivo, the member of MWCOG staff who performed the analysis.


ALL SKYCOMP DATA SAMPLES
(NO SAMPLES UNDER DENSITY OF 20)
SPEED (MPH)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140
DENSITY (PCPLPM)

The main advantages to a single-regime model are that boundaries between regimes do not have to be defined; and curves from adjacent regimes do not have to be spliced at the boundaries. A single-regime model allows for a more subjective and repeatable calibration process. This will be is especially true if more data from the high-speed end of the curve is ever incorporated into this process.

The disadvantages to this particular model are that it expresses this project's independent variable as a function of the dependent variable; and that it is a non-linear function. These disadvantages make performing the initial calibration more difficult. However, once SAS programs for the task are written, they can be used again usually with a minimum of effort.

The procedure for calibration was as follows: 1) The model's equation was coded into a spreadsheet so that the shape could be defined by recognizable parameters: two points that the curve passes through, the free-flow speed, and the speed at capacity. By overlaying this curve with the scatter plot of the observations, initial estimates of the parameters were made. 2) The initial parameter estimates, the equation, and the observations were used in a SAS PROC NLIN job to machine-calibrate the parameter estimates. 3) A second SAS program translated the calibrated equation into a look-up table that expresses speed as a function of density. 4) The results of the SAS work were imported into a spreadsheet for plotting and for calculation of prediction intervals.

Two outstanding technical issues related to this procedure are determination of the free-flow speed, and calculation of prediction intervals.

The free-flow speed for best fit can be determined by the PROC NLIN program, as are all other parameters. Due to the lack of data at the low-density region of the model, PROC NLIN returns a very high free-flow speed. Additional data from MD SHA was used to calculate a free-flow speed for general application on the Beltway. The calibration of the model presented here resulted from forcing the free-flow speed to match the SHA data analysis.

The prediction intervals shown in the current plot were calculated after the model was translated. This may have not been appropriate. PROC NLIN calculates prediction intervals directly as it calibrates the model. Those prediction intervals express density as a function of speed, however. Work is in progress to translate them, and to otherwise arrive at the most appropriate method of determining prediction intervals.
Since a single-regime model is more suitable in a computerized process, and for lack of significant difference in performance, the Van Aerde model is preferred over earlier approaches examined by MWCOG staff and presented before subcommittees.

This model was developed by Michael Van Aerde and described in TRB Paper No. 950802. It differs from the models already presented in two significant respects: 1) The Van Aerde model expresses headway or density as a function of speed instead of speed as a function of density; 2) The Van Aerde model's single regime is continuous for the entire speed range from jam to free-flow.

The model is:

$$D = 1 / (c1 + c2 / (Sf - S) + c3 * S)$$

where:

D = Density (vehicles/lane/mi)

Sf = Free-flow speed (mph)

c1, c2, c3 = coefficients

S = Speed (mph) -- INDEPENDENT VARIABLE

The model was calibrated for local use by MWCOG staff. Maryland SHA ATR data from stations on the Capital Beltway was used to determine the free-flow speed. Skycomp aerial speed/density observations were used to calibrate the coefficients.

The calibration resulted in the curves shown in the attached graphics: Speed vs. Density; Flow Rate vs. Density; Speed vs. Flow Rate; and Speed Residuals vs. Density.

The coefficients required to plot the Density vs. Speed curve are 0.00512, 0.0144, and 0.000342, respectively. The free-flow speed is 67 mph. All trucks were weighted as 2.5 cars. The upper and lower bounds shown on this plot are 95% prediction intervals.

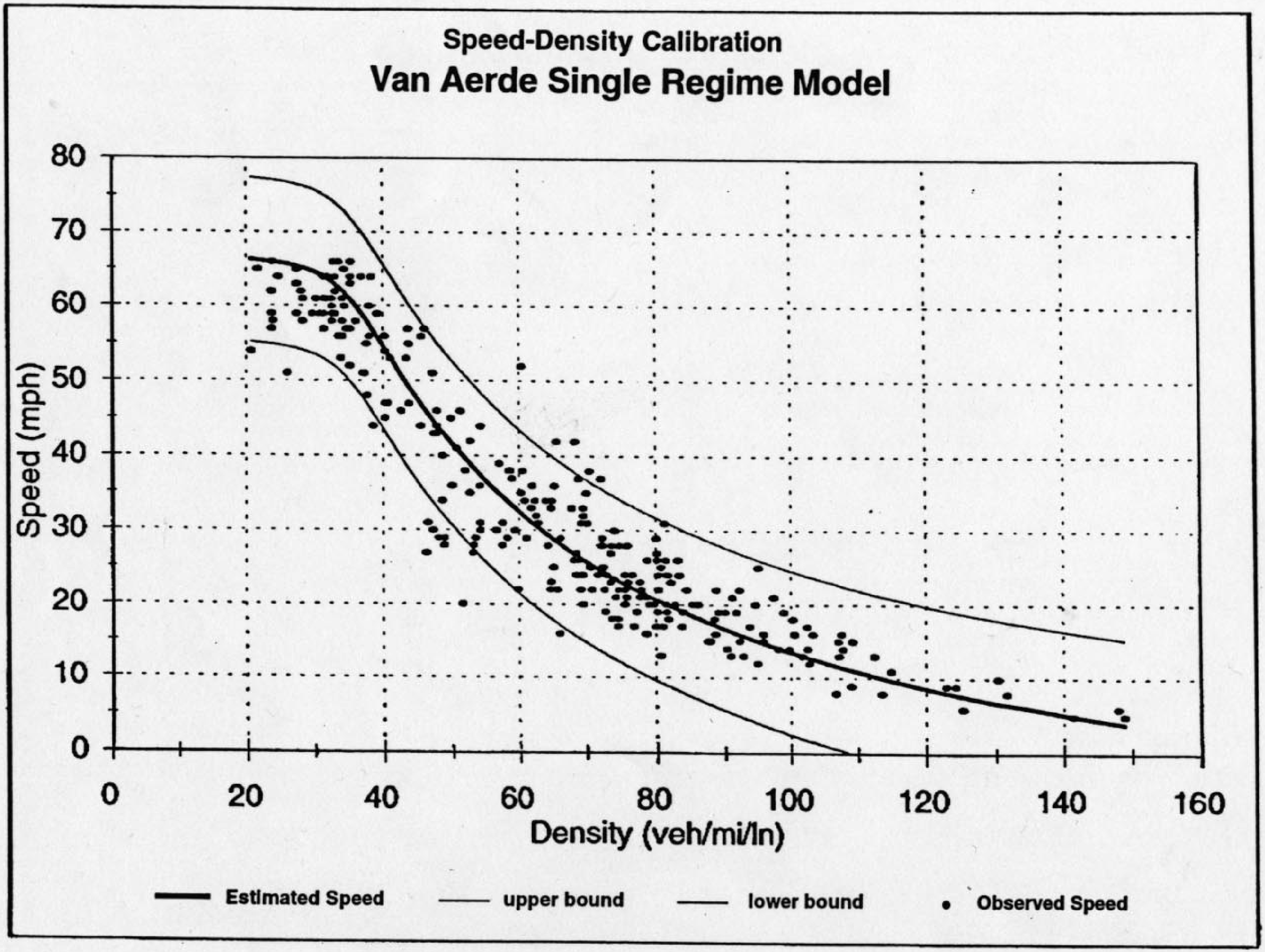
Speed-Density Calibration
Van Aerde Single Regime Model

free-flow spd = 67 mph / c1 = 0.00512 / c2 = 0.0114 / c3 = 0.000342

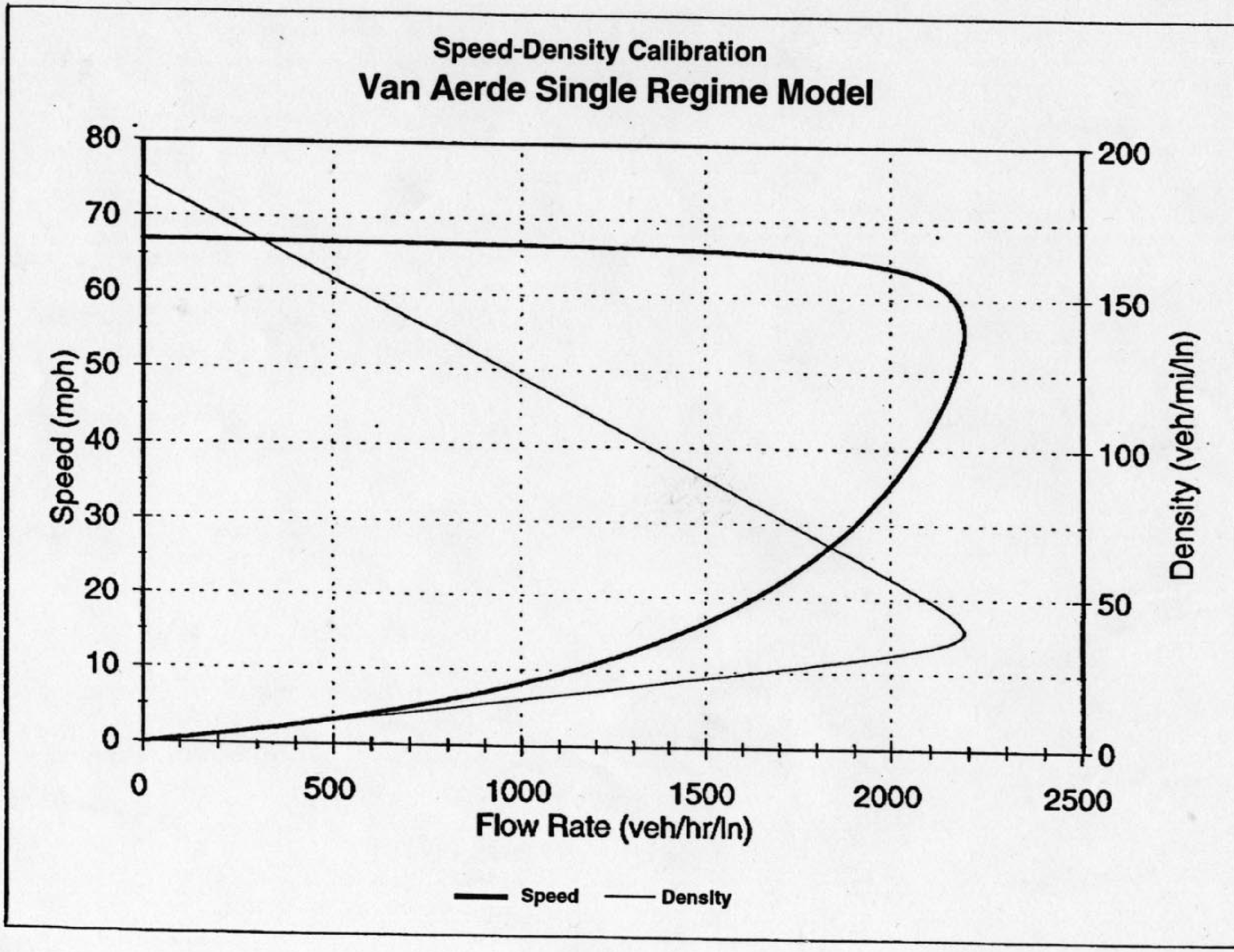
	DENSITY (veh/ln/mi)	SPEED (mph)	VOLUME (veh/ln/hr)
free-flow	0	67.0	0
	20	66.4	1,328
	25	65.8	1,661
	30	64.6	1,946
	35	61.3	2,144
capacity	39	55.8	2,190
	40	54.7	2,189
	45	47.8	2,153
	50	41.9	2,094
	55	36.8	2,025
	60	32.6	1,954
	65	28.9	1,880
	70	25.8	1,806
	75	23.1	1,731

DENSITY (veh/ln/mi)	SPEED (mph)	VOLUME (veh/ln/hr)	
80	20.7	1655	
85	18.6	1580	
90	16.7	1503	
95	15.0	1425	
100	13.5	1350	
105	12.1	1271	
110	10.9	1197	
115	9.7	1117	
120	8.7	1043	
125	7.7	963	
130	6.8	885	
135	6.0	810	
140	5.2	729	
187	0	0	jam

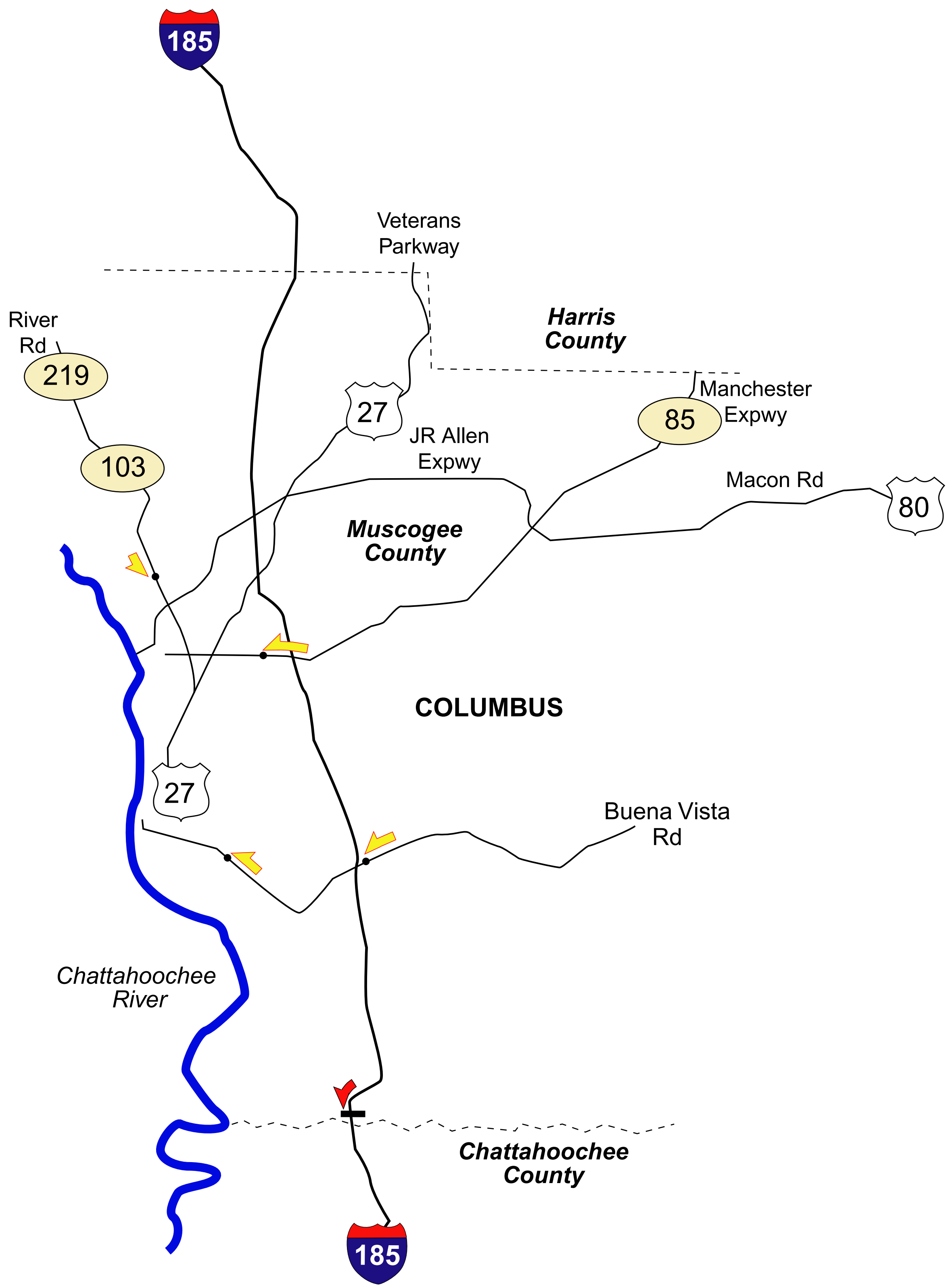
Draft 15 February 1996



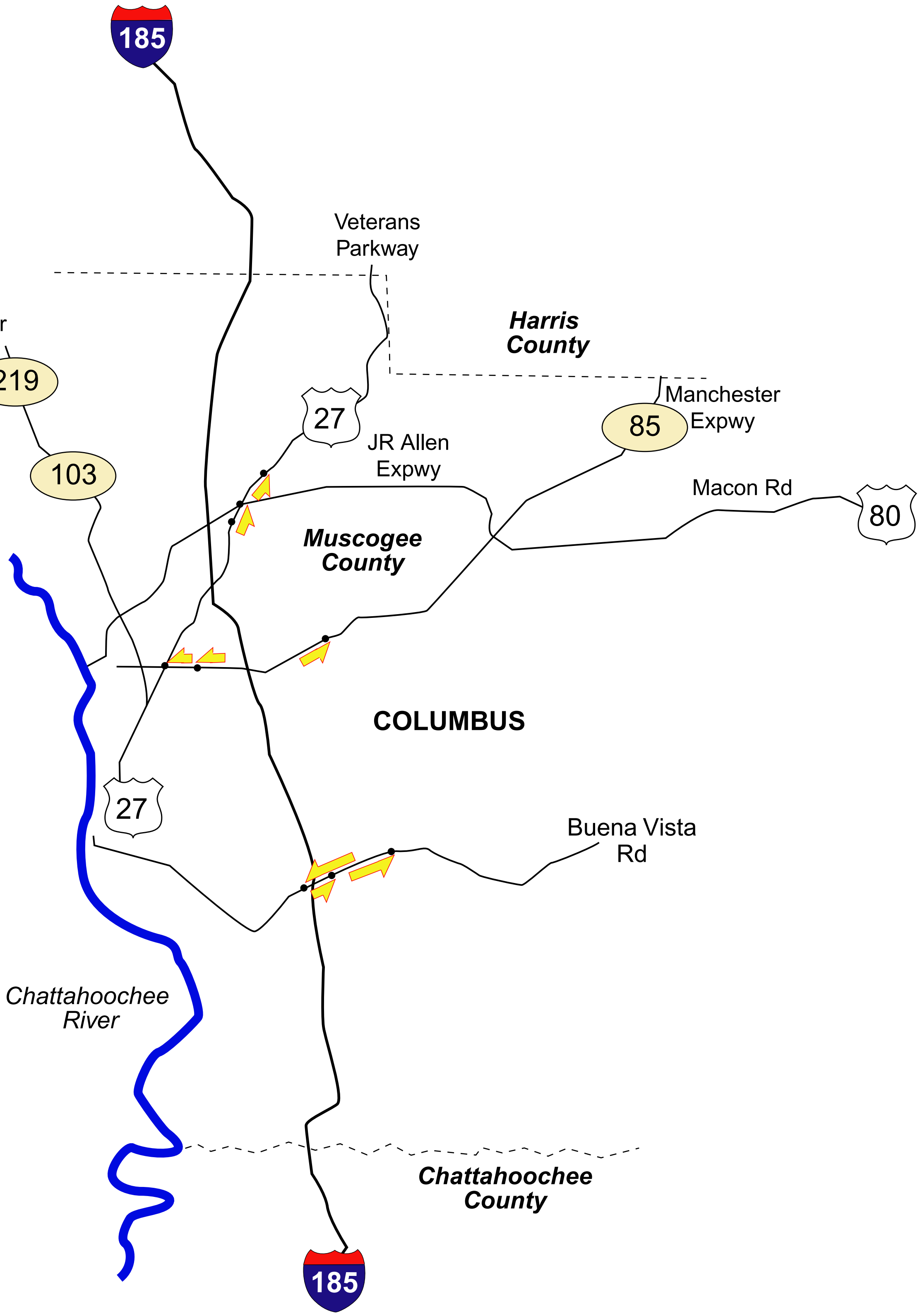
Speed-Density Calibration
Van Aerde Single Regime Model
Speed (mph)
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
Density (veh/mi/ln)
Estimated Speed
upper bound
lower bound
Observed Speed


Speed-Density Calibration
Van Aerde Single Regime Model
Speed (mph)
Density (veh/mi/ln)
Flow Rate (veh/hr/ln)
0
10
20
30
40
50
60
70
80
0
50
100
150
200
0
500
1000
1500
2000
2500
Speed
Density

COLUMBUS, GEORGIA
LOCATIONS WHERE CONGESTION WAS FOUND
MORNING



COLUMBUS, GEORGIA
LOCATIONS WHERE CONGESTION WAS FOUND
EVENING

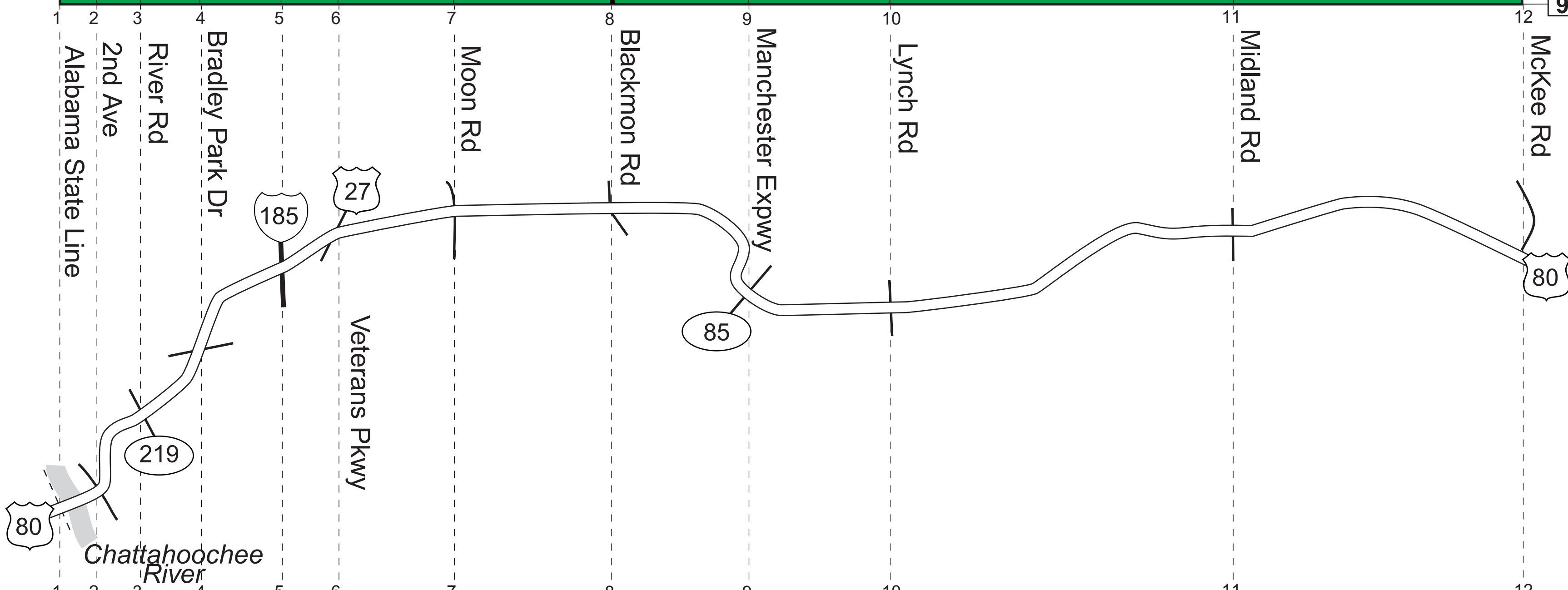


US 80 (JR ALLEN PARKWAY / MACON RD)

(MORNING - FALL 2002)

← WESTBOUND

	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12
7:00 a.m. – 7:30 a.m.	A	B	B	B	A	A	A	C	C	C	C
7:30 a.m. – 8:00 a.m.	A	B	B	B	A	A	B	D	C	C	B
8:00 a.m. – 8:30 a.m.	A	B	B	A	A	B	B	C	C	C	C
8:30 a.m. – 9:00 a.m.	A	B	A	A	A	A	A	C	C	B	B



	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12
7:00 a.m. – 7:30 a.m.	C	B	B	A	A	A	A	C	C	B	A
7:30 a.m. – 8:00 a.m.	C	B	C	A	A	A	A	D	D	B	B
8:00 a.m. – 8:30 a.m.	C	B	B	A	A	A	A	C	C	C	B
8:30 a.m. – 9:00 a.m.	A	B	A	A	A	A	A	C	C	B	B

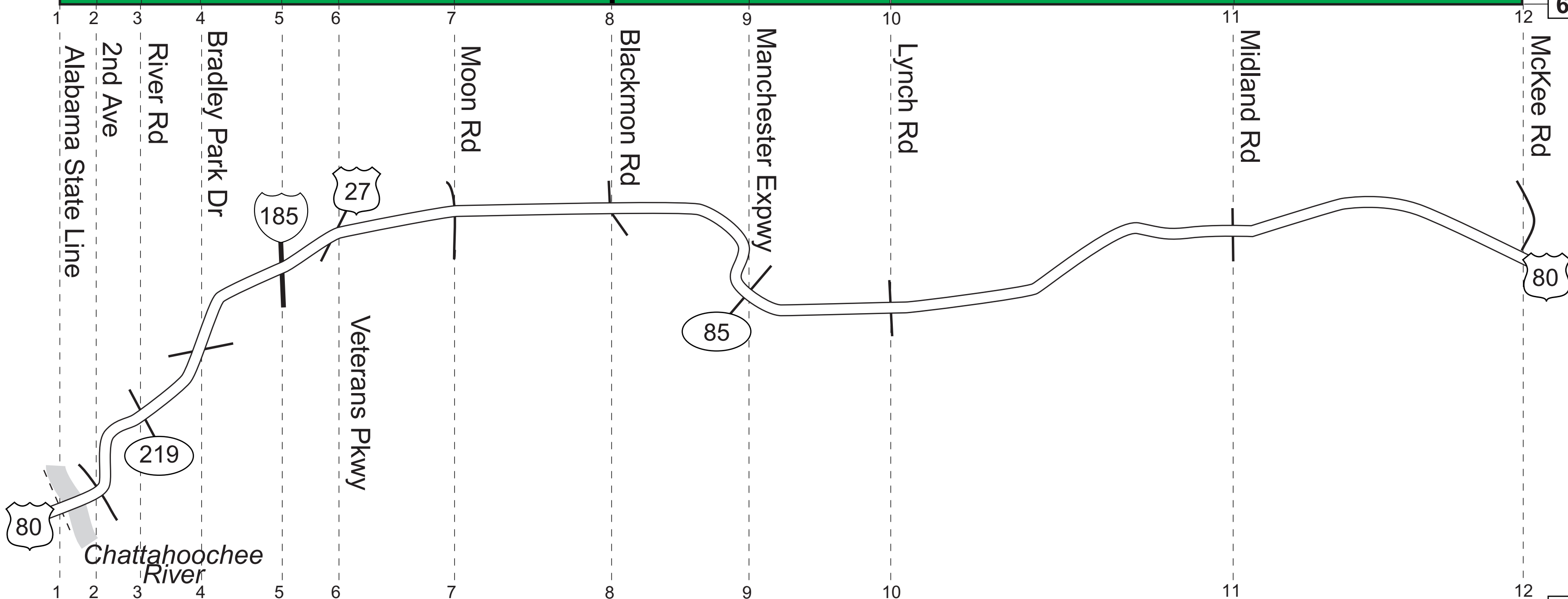
EASTBOUND →

US 80 (JR ALLEN PARKWAY / MACON RD)

(EVENING - FALL 2002)

WESTBOUND

4:00 p.m.	B	B	A	A	A	A	A	C	C	B	A
4:30 p.m.	C	B	B	A	A	A	A	C	C	C	B
5:00 p.m.	D	C	C	A	A	A	A	C	C	B	B
5:30 p.m.	C	C	B	A	A	A	A	C	C	B	B
6:00 p.m.											

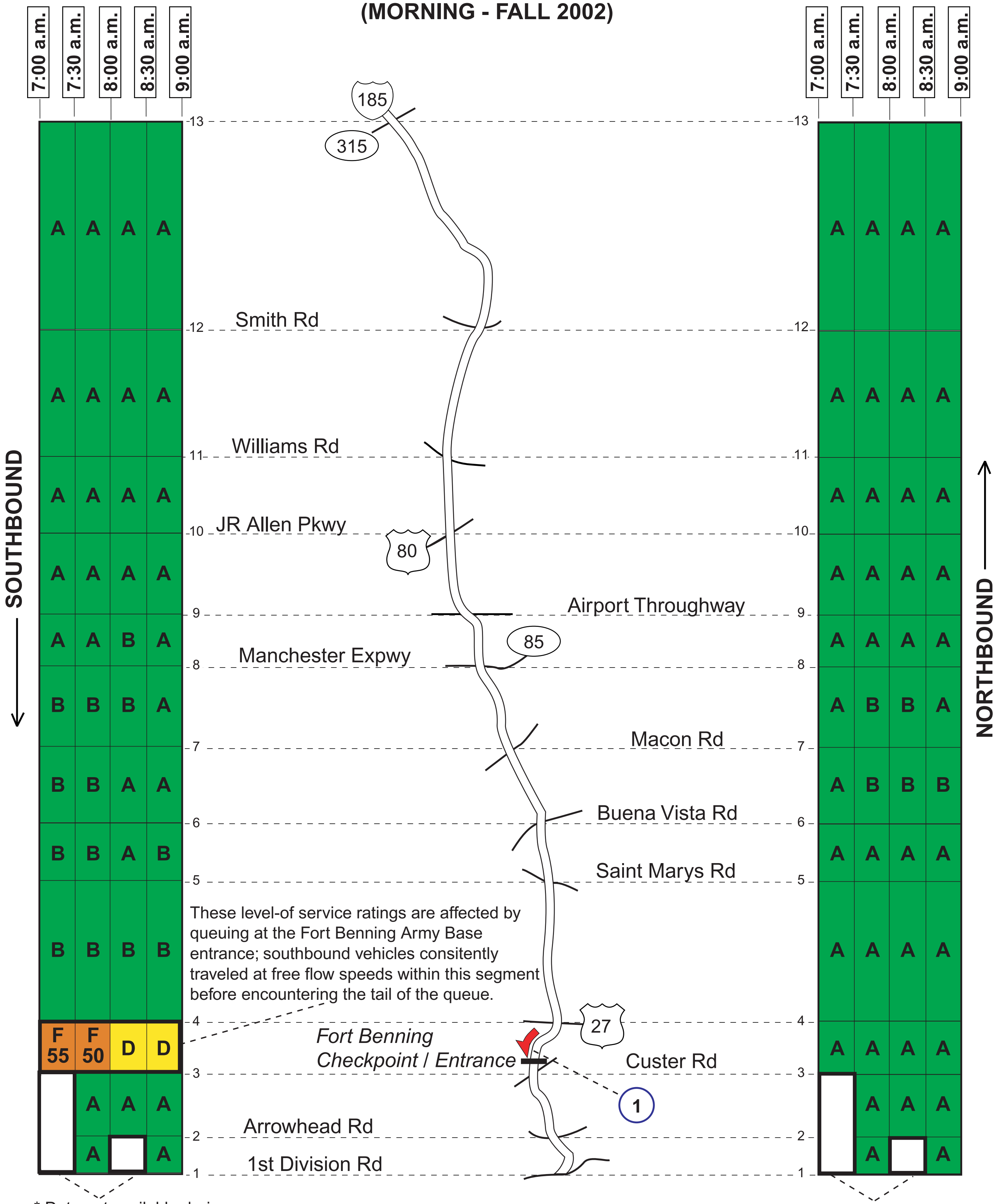


4:00 p.m.	A	A	A	A	A	A	A	C	C	B	B
4:30 p.m.	B	B	B	A	A	A	A	C	C	C	B
5:00 p.m.	B	C	C	B	A	A	A	C	C	C	C
5:30 p.m.	B	B	B	A	A	A	A	C	C	C	B
6:00 p.m.											

EASTBOUND

I -185

(MORNING - FALL 2002)

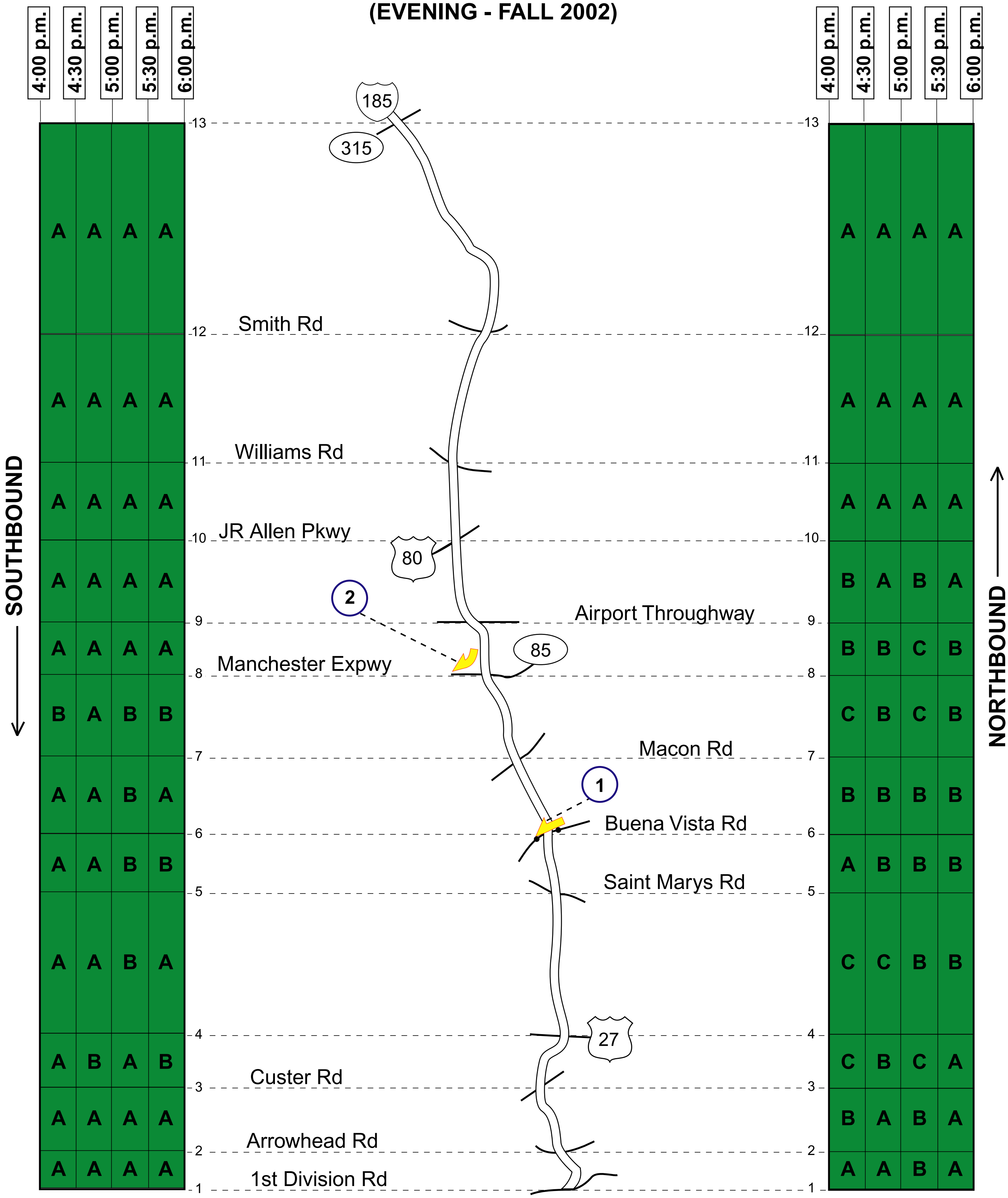


* Data not available during these time periods due to airspace restrictions at Fort Benning Army Base.

* Data not available during these time periods due to airspace restrictions at Fort Benning Army Base.

I -185

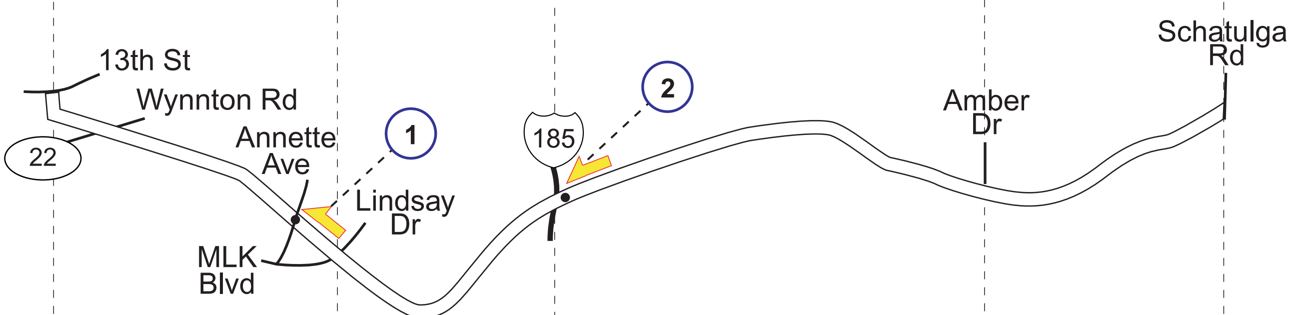
(EVENING - FALL 2002)



BUENA VISTA RD
(MORNING - FALL 2002)

← **WESTBOUND**

Time	1–2	2–3	3–4	4–5
7:00 a.m. – 7:30 a.m.	C	C	C	C
7:30 a.m. – 8:00 a.m.	D	C	E	C
8:00 a.m. – 8:30 a.m.	E	D	E	C
8:30 a.m. – 9:00 a.m.	E	D	D	C



Time	1–2	2–3	3–4	4–5
7:00 a.m. – 7:30 a.m.	C	C	C	B
7:30 a.m. – 8:00 a.m.	C	C	C	B
8:00 a.m. – 8:30 a.m.	D	C	C	C
8:30 a.m. – 9:00 a.m.	C	C	C	B

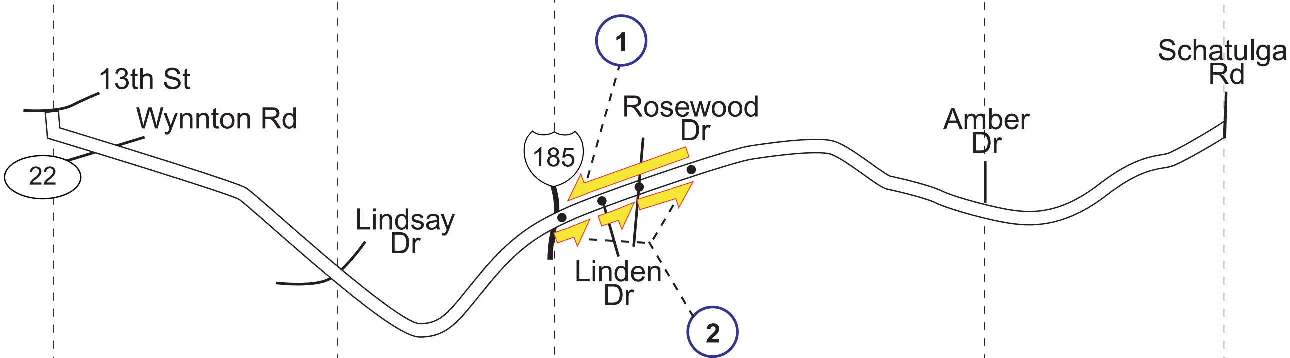
EASTBOUND →

BUENA VISTA RD

(EVENING - FALL 2002)

← **WESTBOUND**

	1–2	2–3	3–4	4–5
4:00 p.m. – 4:30 p.m.	C	D	D	B
4:30 p.m. – 5:00 p.m.	C	C	C	B
5:00 p.m. – 5:30 p.m.	C	C	D	B
5:30 p.m. – 6:00 p.m.	C	C	E	B



	1–2	2–3	3–4	4–5
4:00 p.m. – 4:30 p.m.	D	C	D	B
4:30 p.m. – 5:00 p.m.	D	C	D	B
5:00 p.m. – 5:30 p.m.	C	D	D	B
5:30 p.m. – 6:00 p.m.	C	D	E	B

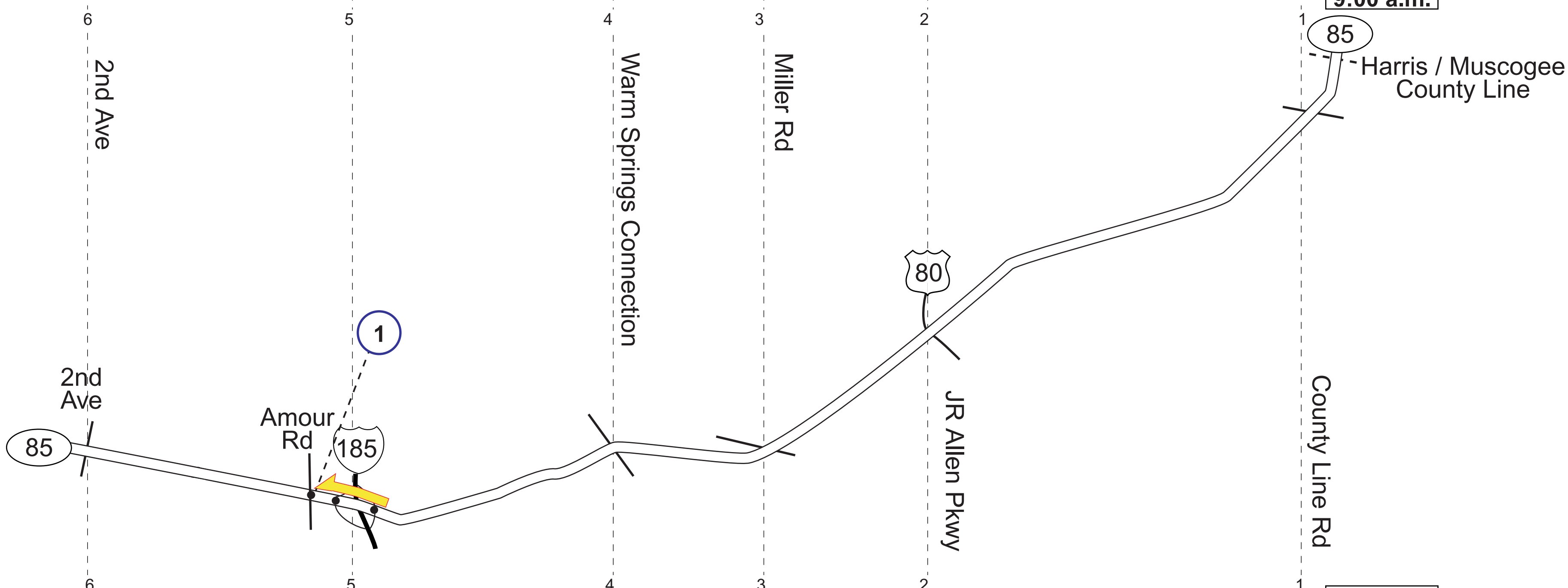
EASTBOUND →

MANCHESTER EXPRESSWAY / SR 85

(MORNING - FALL 2002)

← WESTBOUND

C	C	A	A	A	7:00 a.m.
C	D	B	A	A	7:30 a.m.
E	D	A	A	A	8:00 a.m.
D	C	A	A	A	8:30 a.m.
					9:00 a.m.



C	C	A	A	A	7:00 a.m.
C	C	A	A	A	7:30 a.m.
C	C	A	A	A	8:00 a.m.
C	C	A	A	A	8:30 a.m.
					9:00 a.m.

EASTBOUND →

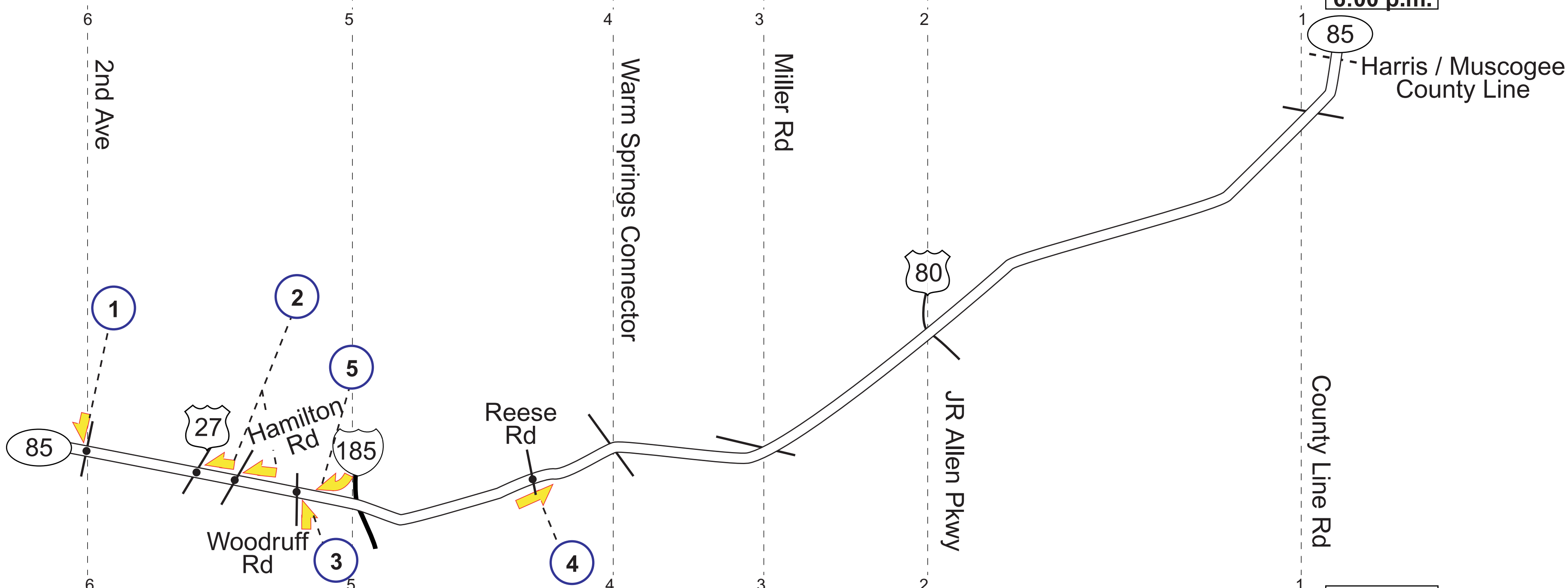
MANCHESTER EXPRESSWAY / SR 85

(EVENING - FALL 2002)

WESTBOUND

C	C	A	A	A
C	C	A	A	A
D	C	A	A	A
E	C	A	A	A

4:00 p.m.
4:30 p.m.
5:00 p.m.
5:30 p.m.
6:00 p.m.

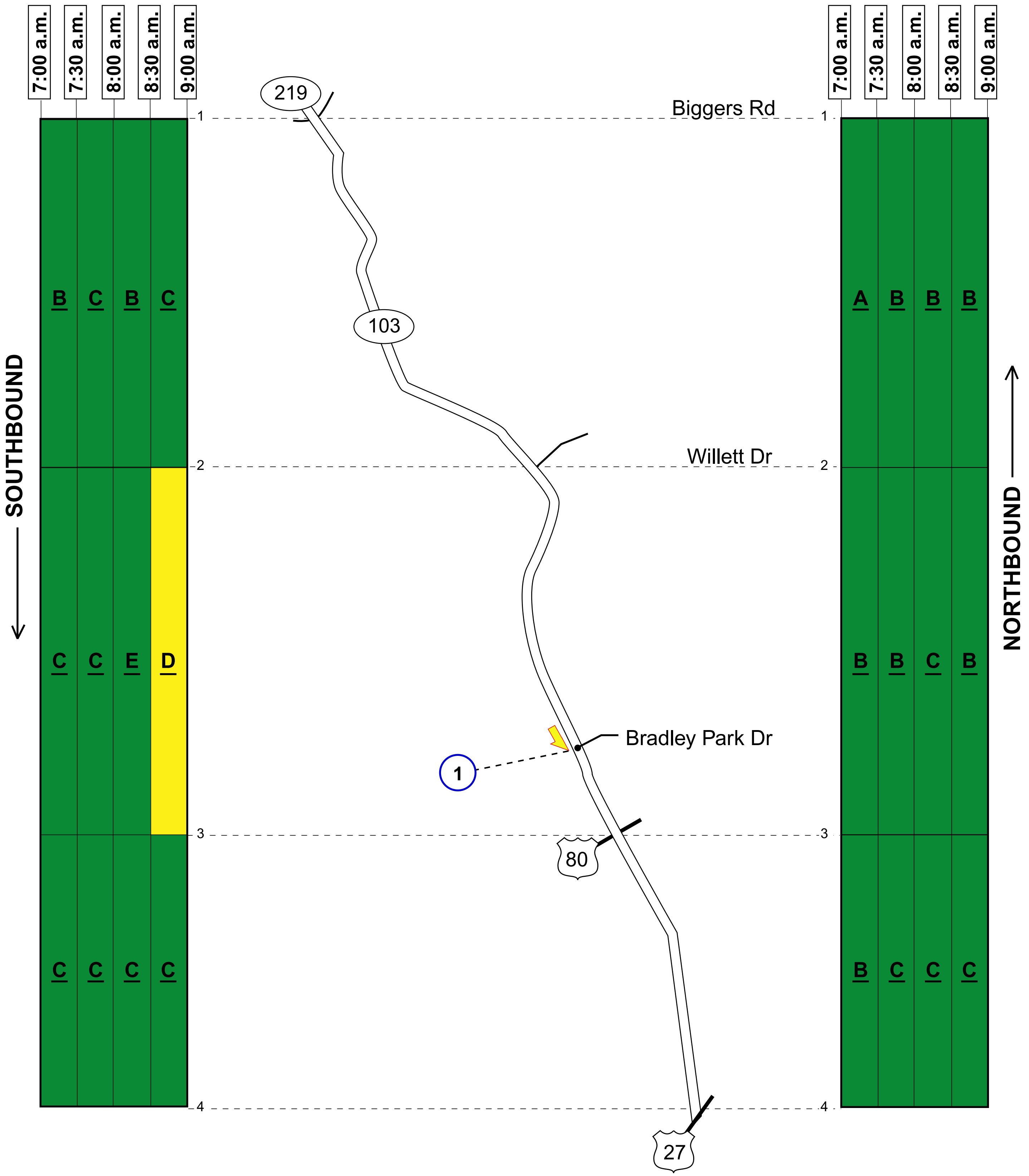


C	C	B	A	A
D	C	A	A	A
D	C	B	A	A
C	E	A	A	A

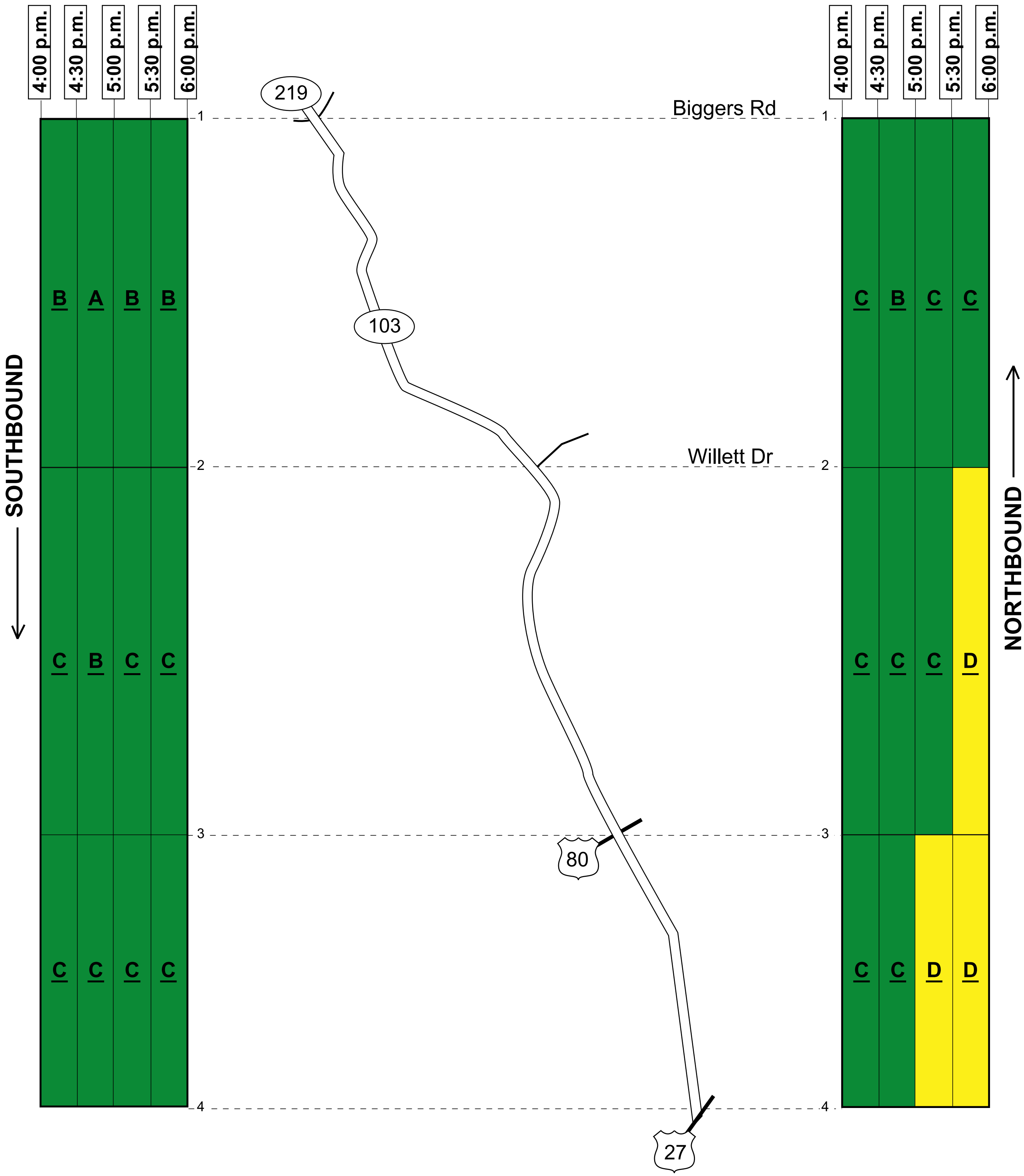
4:00 p.m.
4:30 p.m.
5:00 p.m.
5:30 p.m.
6:00 p.m.

EASTBOUND

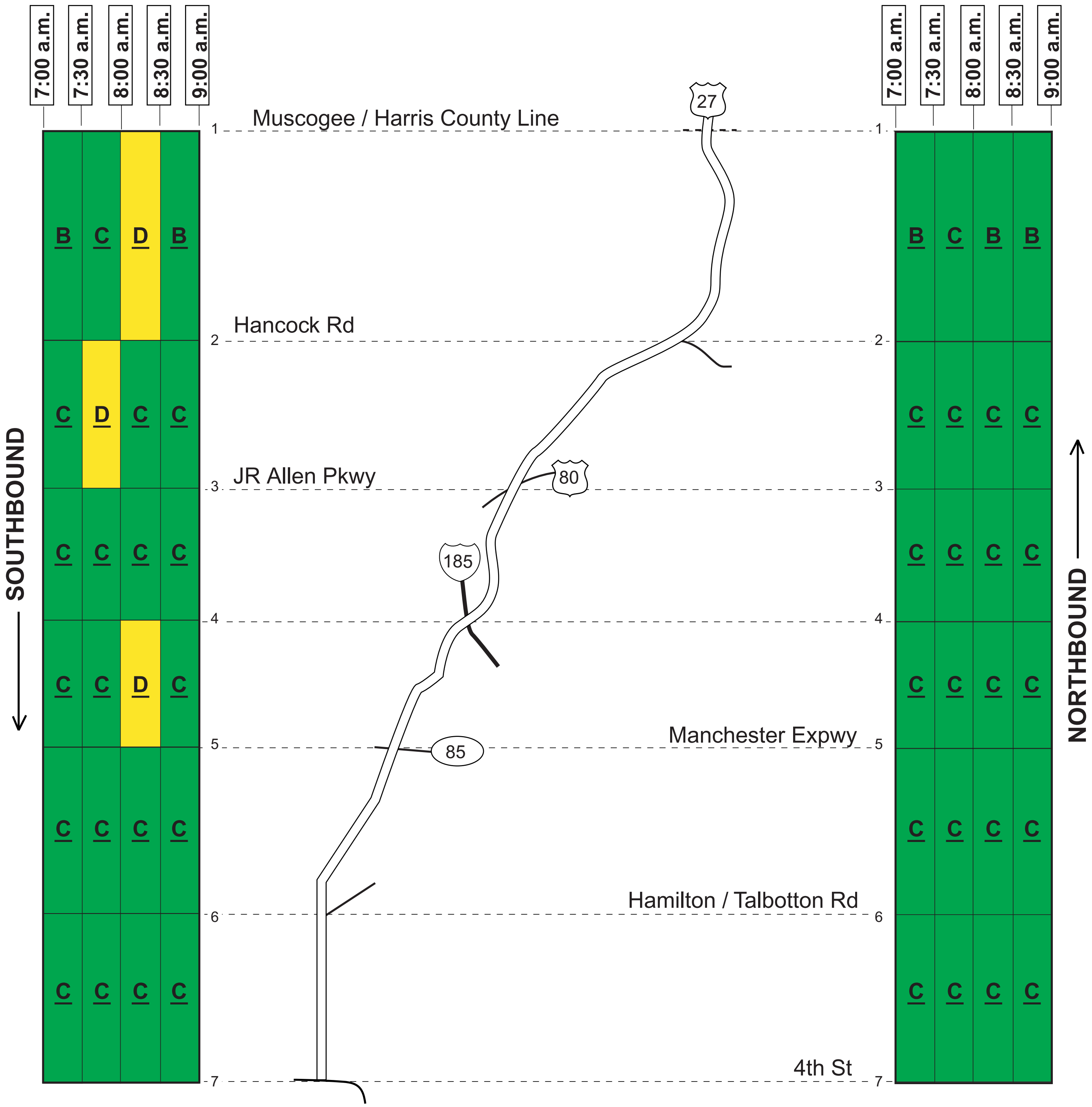
RIVER RD (SR 103 / 219)
(MORNING - FALL 2002)



RIVER RD (SR 103 / 219)
(EVENING - FALL 2002)



VETERANS PARKWAY (US 27)
(MORNING - FALL 2002)



VETERANS PARKWAY (US 27)

(EVENING - FALL 2002)